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OCTOBER 22, 1956

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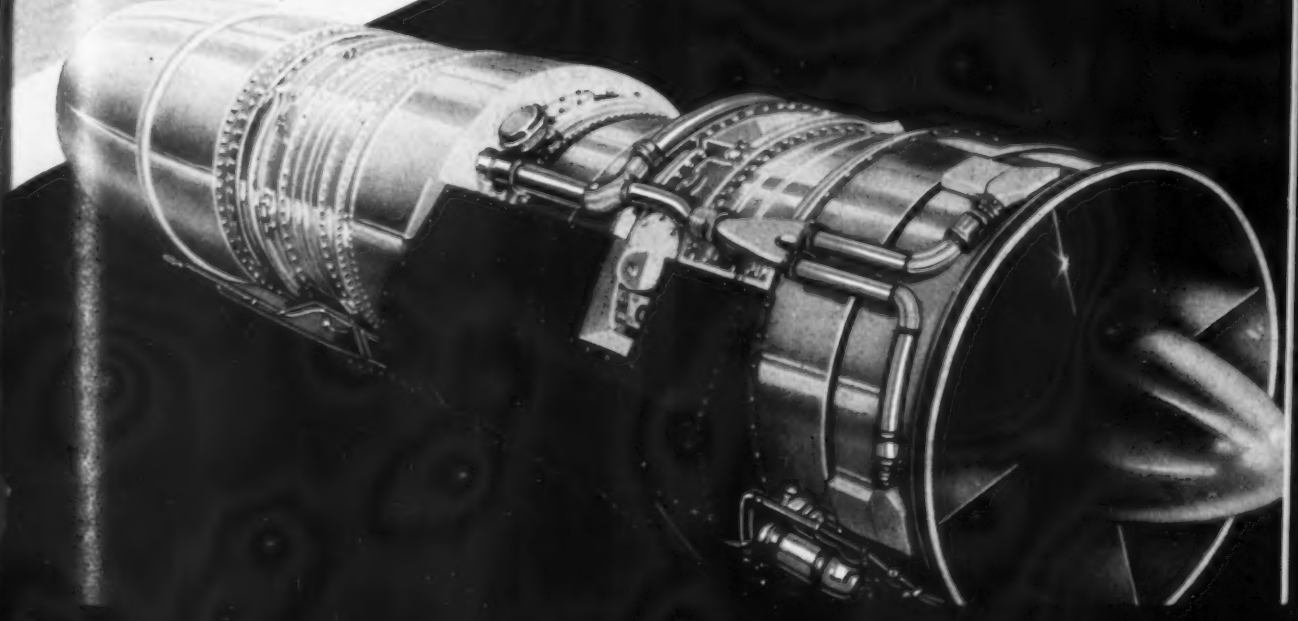

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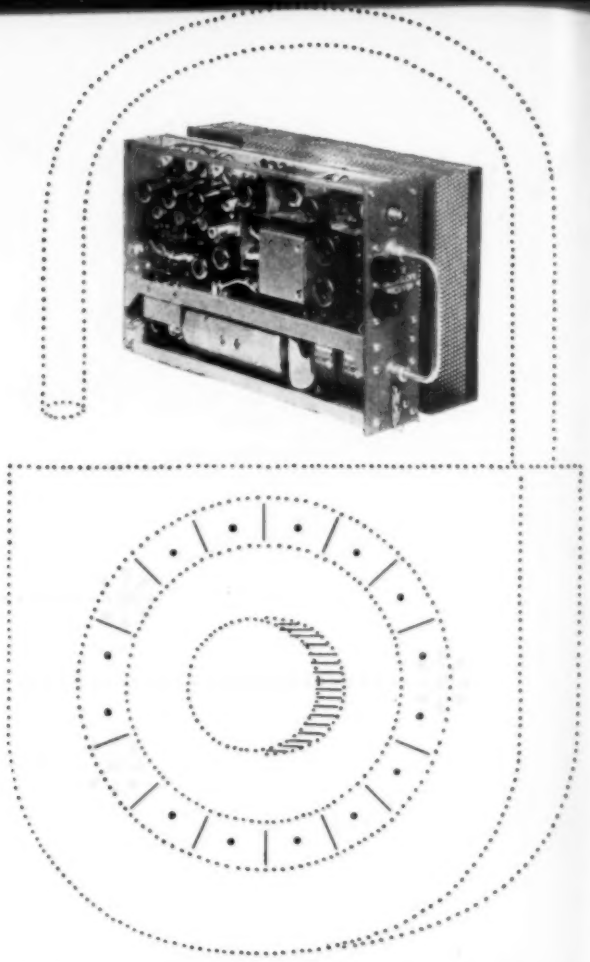

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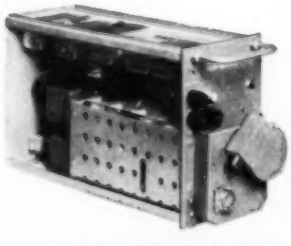

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Official Airline Guide: Monthly publication of airline schedules, fares, World-Wide Edition: $19.50 per year, everywhere, North American Edition: $13.50 per year in USA; $14.00 in Canada; $15.00 elsewhere. Published from 139 N. Clark St. Chicago 2, Ill. Phone: Central 6-5804. Managing Editor—Robert R. Parrish.
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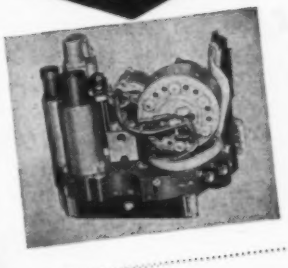

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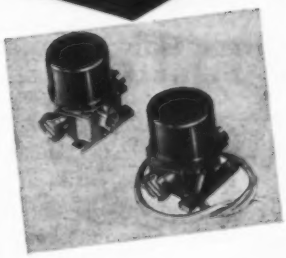

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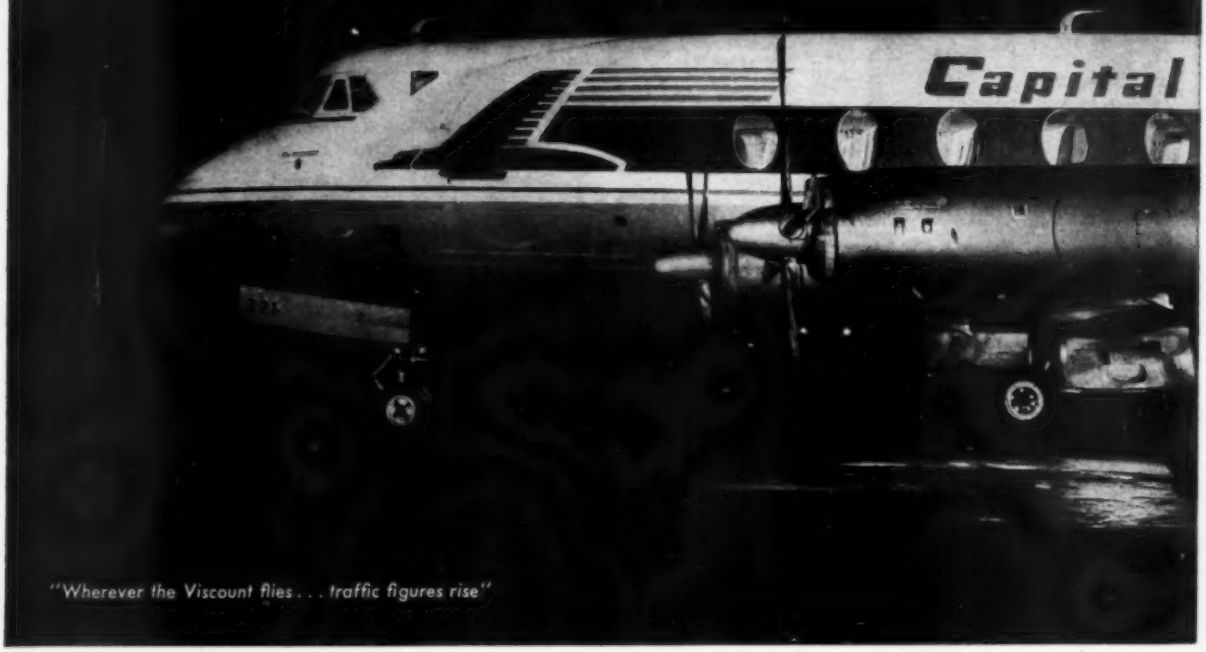

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CONTENTS

OCTOBER 22, 1956 VOL. 20, NO. 11

Fifth Annual Engineering & Development Issue

52,000 copies of this issue printed.

RELIABILITY FEATURES

The Military Importance of Reliability, by Frank D. Newbury 35
What AMC is Doing About Reliability, by Col. H. G. Spillinger ... 36
West Coast Manufacturers Agree: Reliability Improving 39
New Engines Pose Wide Variety of Problems 42
What's Ahead in Field of Jet Fuels, by Aubrey Keif 46
Exide Program to Insure Battery Reliability 48
Sound Design: Basic Ingredient of Reliability, by J. M. Bridges 50
A Reliability Science Desperately Needed 56
Copters: How Close to Reliability? 72
Russian Approach to Reliability 151

•

OTHER FEATURES

Heat 'Barrier':
- Problem of Heat 76
- High-Speed Heat 84
- Tooling and Knowhow 92

Why Present Windtunnels Are Inadequate 98
How U.S. Tackles Problems of IRBMs, ICBMs. 113
U.S. Missile Arsenal 118
Best New Products and Processes of 1956 122

•

DEPARTMENTS

Personal View 9
Letters 12
Production Spotlight 16
Books 21
When and Where 26
People 154
West Coast Talk 156
Industry News Digest 158
Facilities 180
En Route 184

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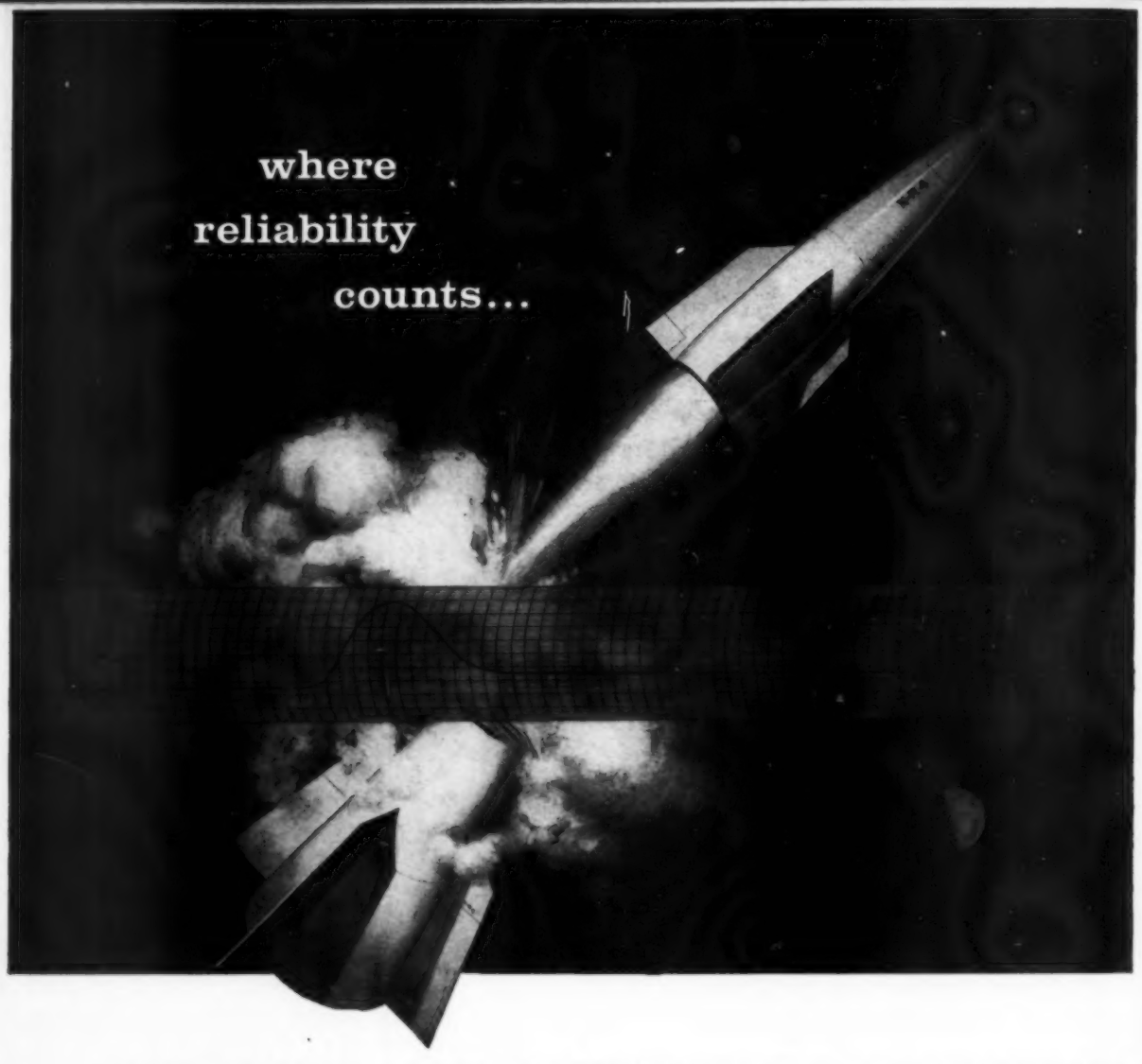

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Personal View

By WAYNE W. PARRISH

Heartfelt Thanks to Ford

IT WAS LATE in the afternoon on a rather dreary Friday a few weeks ago. The telephone rang. A Mr. John R. Morris of Ford Motor Company was calling from Dearborn.

Mr. Morris started his conversation by referring to an editorial we had written last April. Okay, another complaint, we thought. Editors are accustomed to getting more gripes than praise. We've learned to take them in stride.

But as Mr. Morris continued to talk, a great light began to shine. Far from complaining about something, Mr. Morris was advising us in advance that one of our editorials had really hit the jackpot.

It had been so long ago that we'd forgotten all about it. But last April we had written a crusading plea for our automobile manufacturers to contribute some new models of their cars to our embassies and legations behind the Iron Curtain as showpieces of our great and advanced industrial civilization. Our government, which can pass out billions at the drop of a hat, maintained fleets of old, plain and battered American cars that most people here wouldn't want parked in the front of their houses. The Russian public could well afford to believe their government propaganda about the decadent U.S. by merely seeing what the Americans in Moscow were driving around.

We sent copies of that editorial to the presidents of the three largest automobile companies, and also to various top individuals in and close to the White House executive offices. Except for perfunctory replies from the automobile companies, plus considerable favorable reaction from our readers, we had heard nothing in the way of tangible results.

Mr. Morris said that since our editorial was directly responsible for a project now under way, he thought it only fair to call us in advance. He said his company had flown one 1957 model Ford to Helsinki with great secrecy and it had gone the rest of the way by train and would be unveiled in Moscow before the general unveiling in the U.S., and that a half-dozen more new Fords including a station wagon, plus a fine new Lincoln, were on the way over. All the cars were sold to the U.S. for $1 each.

All we could think of to say was "God bless you."

The Ford Motor Company has performed a patriotic gesture which will be more appreciated abroad than at home where the timid, vacillating State Dept. boys shun any action that smacks of anything fine and great about American production and achievement. We feel strongly that the U.S. with its vastly superior and vastly more abundant way of life should stop apologizing and cringing, and put its best foot forward. We should be justly proud of what we have.

It is hardly to the credit of the powerful General Motors, or to Chrysler (which could have replaced our ambassador's antique Chrysler in Moscow long ago), that they muffed the ball. But it is to the great credit of the Ford Motor Company that it had the initiative to make a real contribution to the national interest. More power to Ford and its products.

We hope our readers will pardon this little burst of editorial pride. It isn't often that editorials pay off, or at least pay off so handsomely. Our motive was not only completely unselfish but had its origin in a fierce pride in the United States which got even more intense after seeing the dreary and drab life in the east. We wish our State Department people had a similar pride and interest. The impact of the Ford gesture will be great. So hats off to Ford.

Missiles and Rockets

Having just patted our editorial self on the back in the space above, perhaps we may be pardoned further by taking note of a genuine surprise which occurred subsequent to the Ford Motor Company call.

Again it was the ringing of a telephone that brought the news. A staffer for the Washington Bureau of *Time* magazine called just before noon on Tuesday, October 9 to break the news that the editor of this page had landed with a splash in the Press section of *Time* for October 15.

That *Time* staffers had been working on such a story was no secret but the intake of news and data into the *Time* editorial offices is much vaster than the distilled product which gets into print. The news takeoff, of course, was the impressive debut of the new monthly magazine, *Missiles & Rockets,* launched this month by American Aviation Publications.

Acknowledgment of this and other achievements of AAP by *Time* is, needless to say, a matter of considerable distinction. It is, in fact, a most satisfying recognition for the almost twenty years of sweat, tears and fun that have gone into building up the nine air age publications and services of which this magazine is one.

Lead plane wins 1900-mile dash by 21.3 seconds as . . .

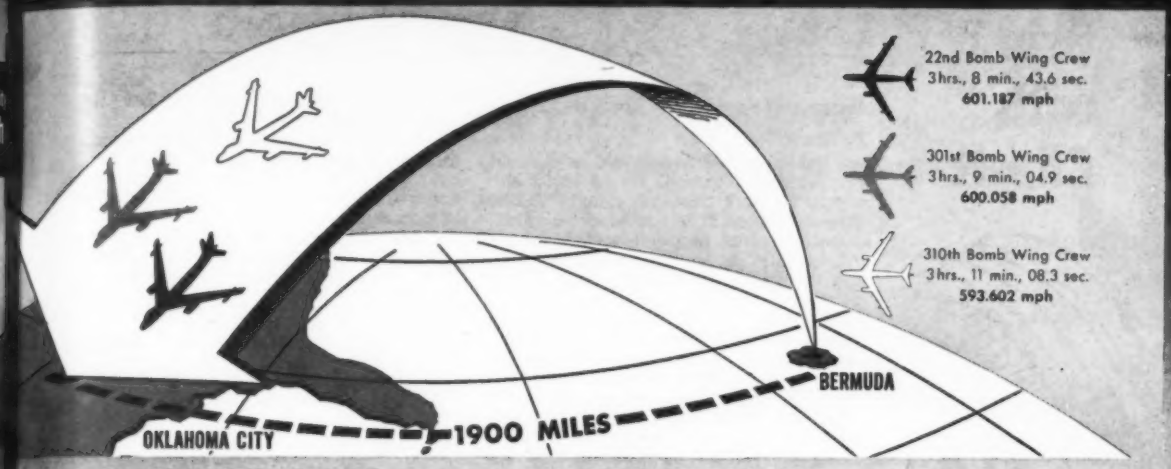
ALL THREE SAC B-47's BREAK SPEED MARK IN GENERAL ELECTRIC TROPHY EVENT

Bermuda-Oklahoma City race emphasizes mobility, readiness of SAC, demonstrates performance, reliability of G-E J47 engines

CONGRATULATIONS are extended to Major J. Schreiber, commander of winning plane, by General E. W. Rawlings, AMC Commander.

TROPHY PRESENTATION. (l. to r.) Capt. D. O. Peterson, Tech. Sgt. J. Richardson, Major J. Schreiber, Major C. J. Luecke, George Fouch, head of G-E jet engine manufacturing, Maj. Gen. W. O. Senter, Commander, OCAMA.

NATION-WIDE TELECAST announced event record to 30,000,000 viewers of G.E.'s Sunday night TV Theatre shortly after race ended.



Averaging 601.187 mph, SAC's 22nd Bomb Wing crew landed its Boeing B-47 only 21.3 seconds ahead of the runner-up aircraft to win the 1956 General Electric Trophy.

Near "photo finish" times logged in the 1900-mile, non-stop dash demonstrate the reliability of the General Electric J47 turbojet. Flying the race into the face of challenging west-to-east prevailing headwinds for the first time, each entry broke the existing Trophy Event B-47 speed mark of 589.294 mph set in 1955.

Eighteen engines—all with throttle settings at maximum allowable power—performed so precisely that only 144.7 seconds separated the competing bombers at the finish line.

Powerplants with this same demonstrated reliability are in service today with more than 1500 SAC B-47's. In this respect, this year's G-E Trophy Event emphasized dramatically the combat mobility and readiness of USAF's Strategic Air Command. General Electric Company, Cincinnati 15, Ohio. 235-11

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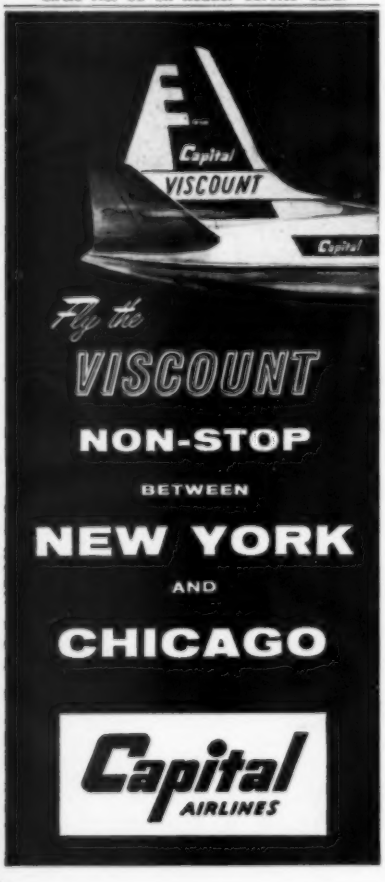

Letters

Housecleaning Needed?

To the Editor:

I think something should be done in your excellent journal (1) to assist the wonderful work the ATA committee has done on Phase I of the no-show minimum-time-limit program, and (2) to aid the industry to present a united front, and to remove the industry from future criticism, when Phase II goes into effect February 1, 1957. If this whole program breaks down anywhere this fall and winter, a lot of responsible people see the only alternatives as (a) further government intervention or (b) ten years will elapse before the problem has another chance to be solved.

What I have in mind is that the industry itself should be fully warned before February 1 that *unless they clean up the telephone and staffing mess in their own reservations office*, our customers will surely have us vulnerable by February 1 on the matter of trying to reach us for cancellations. Saying it another way, we are going to (1) teach the public to come in and get his ticket and (2) penalize him later on if he doesn't learn. But what are we doing to clean our own house first?

To emphasize the point, my men waste literally hours trying to get in and clear space on other airlines in Los Angeles. Yesterday, I heard one major carrier is short 33 agents in their reservations office in Los Angeles. If this is the case between lines, what is the public going to face next spring? Even now, what are they facing?

I do think some feature article should be done on reservations office communications and staffing, in the interest of the whole scheduled industry.

(Name withheld by request)

Oakland's Air Fair

To the Editor:

I read with considerable interest in "Personal View" the article entitled "The Aircraft Show Needs a Change."

We held an "Air Fair" on Sunday, September 16, 1956 on the Metropolitan Oakland International Airport, which was attended by over 120,000 citizens of the East Bay Area. The show was sponsored by the Oakland Junior Chamber of Commerce, the Naval Air Station, Oakland, and the Port of Oakland, operator of the airport. No admission fee was charged and there was considerable flying by the military and civilian commencing with a fly-in breakfast for 320 private pilots and their friends. There were many static displays, both military and civilian, and United Air Lines and Southwest Airways carried over 600 sightseeing passengers, most of them first riders. A great many more could have been flown if equipment had been made available by the airlines.

Our "Air Fair" is an annual event, has been staged for a number of years, and has been very successful. The main purpose of the "Air Fair" is to promote goodwill for aviation in the area and to highlight the airport and its operations and to present the latest military and civilian aircraft, both in the air and on the ground.

We heartily agree with the recommendations proposed in your article and want you to know we have already been doing for some time just what you recommend.

We will be pleased to share our experiences and knowledge with others who may be interested in planning an "Air Fair" of this type.

DON W. MARTIN
Manager, Metropolitan Oakland International Airport
Oakland, Calif.

Disagrees on Show

To the Editor:

You have editorialized (September 24, 1956) that the "National Aircraft Show" needs a change, and that the military services stage their own local and regional shows.

This would be wonderful, I agree, but why sacrifice a Cadillac for a couple of Model "A" Fords? As you have suggested for our State Department—let our embassies have the newest and brightest model cars, to advertise our great productive ability, etc.

To me the fabulous military spectacular that was put on at Oklahoma City, under the able promotion of F. C. Crawford and B. T. Franklin, is the one big tribute and opportunity for the United States aviation industry to display its collective wares. To settle for anything less would be to take a back seat to big shows that are developing in other ambitious countries hungry for America's place as the leader in aviation.

The "one big show" idea resembles the stature and greatness of American Aviation. If other shows can be promoted—fine. But, let's keep the national aircraft show the biggest and best aviation display possible.

ROBERT D. SHEA
Manager,
Cuyahoga County Airport
Cleveland, Ohio

We Think So, Too

To the Editor:

I should like to take this opportunity to thank you for the excellent presentation of Colonial Aircraft Corp. and the smaller executive aircraft manufacturers as published in the August 27 issue of AMERICAN AVIATION.

It is our feeling that your review of the business flying field shows a deep insight into the basic problems related to this type of operation. Continued reporting of this calibre should make AMERICAN AVIATION the publication of major interest to operators of executive aircraft.

I trust that your good work will continue, and you may be assured of our complete cooperation should additional information be required in the future.

DAVID B. THURSTON
President
Colonial Aircraft Corp.
Sanford, Me.

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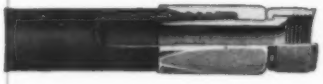

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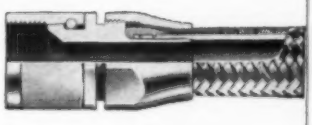

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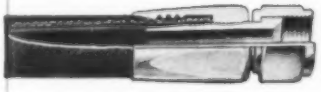

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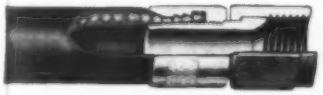

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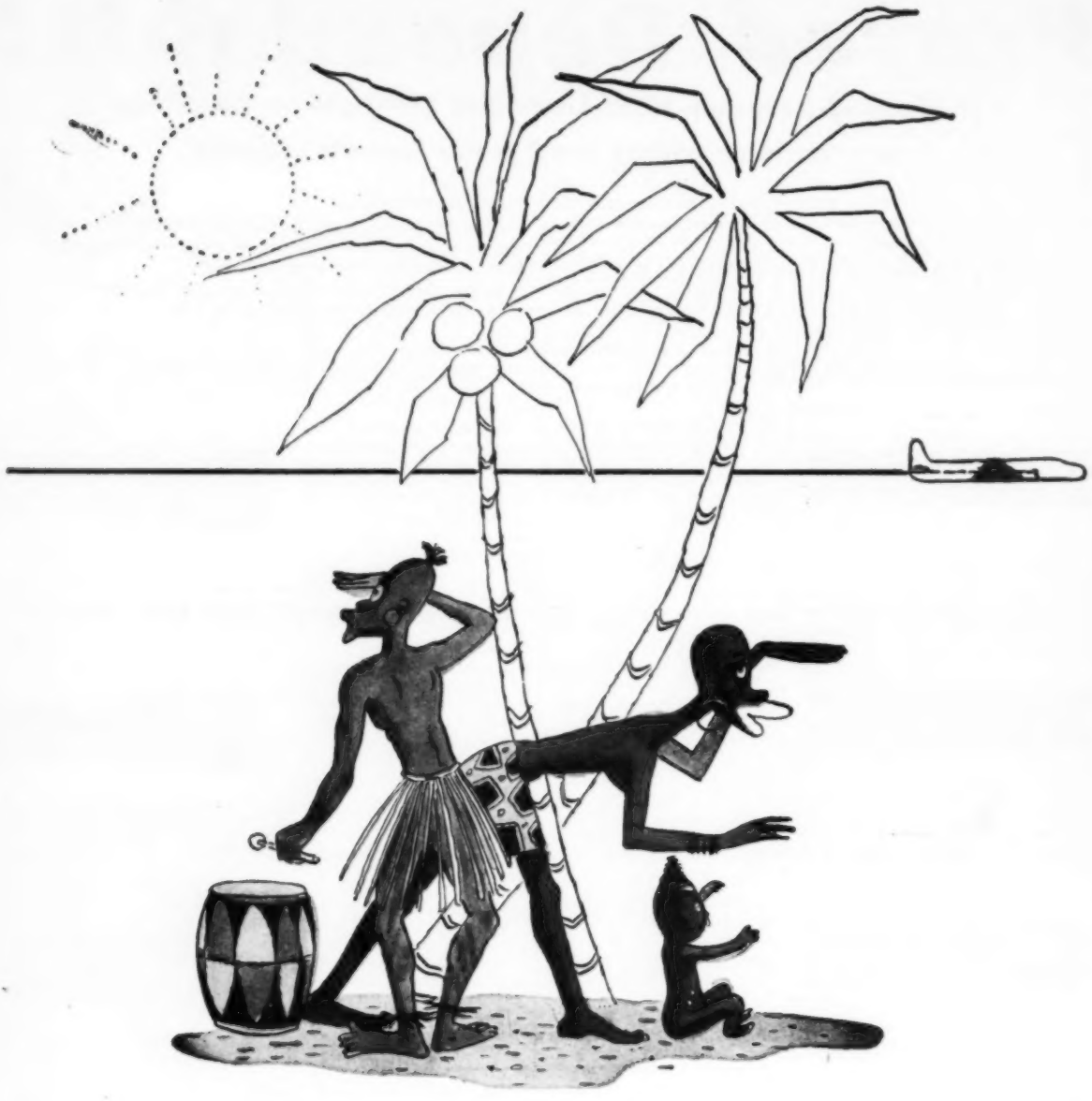

Around the equator 1,500,000 times!

Passengers on the scheduled air fleets of the world last year logged 38 billion miles—enough for one passenger to fly around the equator a million and a half times! This figure represents a gain of 18% over total passenger miles flown in 1954. And this amazing record is expected to be broken again in 1956.

As more and more people fly more and more miles, new and better planes are being developed to serve them. To keep these planes flying, operators know they can rely on Esso Marketers for the finest in modern aviation fuels and lubricants—perfected through years of research—and for the finest in uniform, safe and efficient petroleum service along the airways of the world.

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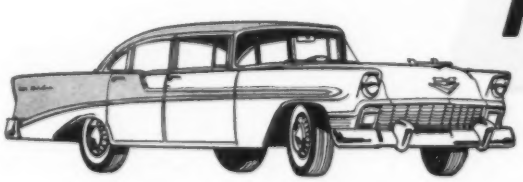
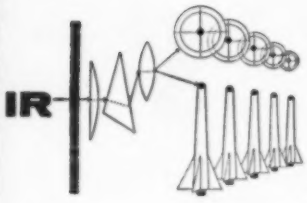


INFRA-RED IS ULTRA-MODERN



In the post-war years, the development of infra-red devices has attained the dimensions of a technological breakthrough. In this period, the Electronics and Guidance Division of Aerojet-General Corp. has become the national leader in the development and manufacture of infra-red equipment.

Aerojet offers qualified engineers and scientists unparalleled opportunities in every area of the guidance and propulsion field.

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Write: Director of Scientific and Engineering Personnel, Box 296H, Azusa, Calif. or Box 1947H, Sacramento, Calif.

Production Spotlight

• Latest commercial jet engine designation at Pratt & Whitney is JT9, presumably its entry in turbofan or bypass category. P&W J52, now being considered by both Douglas and Boeing for their small jet transports, is designated JT8. It is a two-spool design rated at about 7,500-lbs. thrust.

• Thieblot Aircraft Co., Inc. will build C-46 powerplant modification kits under $1-million contract with Aircraft Engineering Foundation. Deal originally was slated to go to Aeronca, but latter couldn't meet early delivery deadline needed by Foundation to satisfy January 1, 1957 date set by CAB for aircraft to be modified.

• Area rule is being applied to the NATO-sponsored Breguet 1001 Taon lightweight fighter. Aircraft should be flying by next spring.

• Germany's BMW is building the Lycoming GO-345 under license at its Allach plant. Engine will power Dornier Do-27 and Piaggio P.149D, which are to be built in Germany.

• Sud-Est's Caravelle jet transport probably will be demonstrated in U.S. next February. By then there should be official word of availability of a version with American engines instead of present standard Rolls-Royce Avons.

• Convair F-106, originally designated F-102B, will make its first flight later this year. F-106, powered by a Pratt & Whitney J75, retains F-102 delta-wing configuration.

• Vickers is looking for a batch of Viscount orders from Latin America in the near future. Argentine Airlines has shown considerable interest.

• Beech Aircraft and Army are negotiating an L-23 modernization contract, calling for three-bladed props, supercharged Lycoming engines, oxygen equipment and additional navaids for the twin-engine courier aircraft.

• Douglas is offering airlines a commercial version of the four-turboprop C-133. Planes would be suitable for transcontinental, transocean cargo operations.

• France's Ouest-Aviation is working on a variety of missile projects, including strategic versions with an entirely new guidance system, a long-range ground-to-air vehicle—of which Trident is a piloted prototype—and a missile for the Vautour bomber.

• France's Hispano-Suiza is building three prototypes of its R800 3,000 lbs. plus engine with its own funds in a bid for small turbojet market.

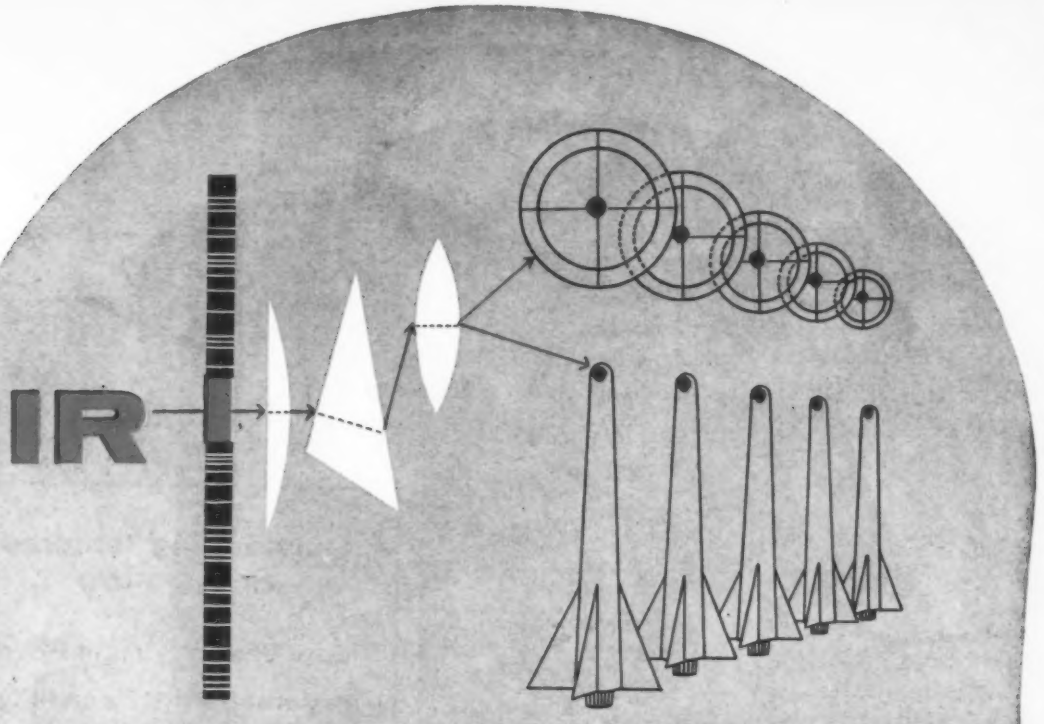
• Fairey's second Rotodyne will have wider fuselage than first so it can accommodate cars. Silver City Airways, British car ferry airline, is interested in the convertiplane.

• Mitsubishi Heavy Industries' aircraft division has been named Nagoya Aircraft and will operate independently of parent company. Plant currently is building 180 North American F-86Fs under license.

• Hughes Aircraft's fire control system goes on Canada's new CF-105. An advanced system, now under test, is scheduled for Convair's F-102B.

• Marquardt Aircraft now boasts a 24-hour, round-the-clock operation. Recently put on a 27-man "graveyard" shift.

• Lockheed has had some conversations with Eastern Air Lines on the staggered seating idea for the latter's Electras. This would up the seating capacity by alternating rows of four and five abreast.



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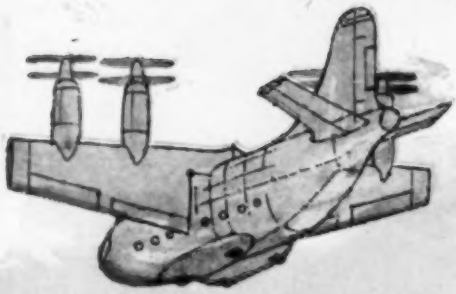

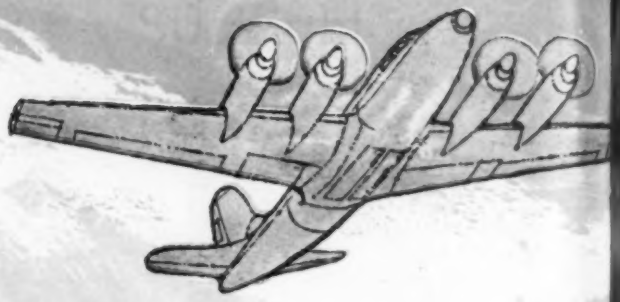

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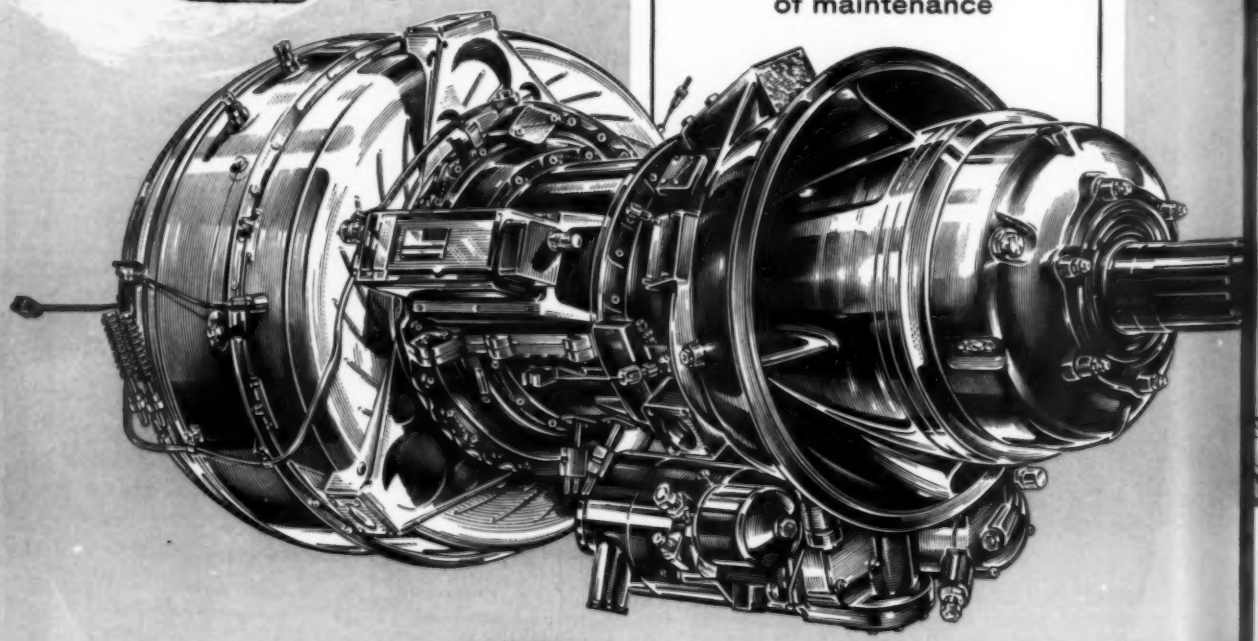

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For the rapidly expanding field of STOL and VTOL aircraft, the new Lycoming T-53 offers a more challenging potential than any turboshaft engine ever developed in the "small-power package" range.

Developed under the sponsorship of the U. S. Army and the U. S. Air Force, the T-53 has already been selected to power the Army' newest Utility 'Copter (Bell XH40). Bell and Kaman have received their flight test engines. Even now the T-53 is being installed in boats, and stationary power plants are under consideration. Yet it is in the field of turbo-prop applications that the T-53 might very well offer its most exciting possibilities.

Ready to take to the air, the complete turbo-prop weighs only 460 lbs. and delivers 960 h.p. from a compact 47.6 length x 23-in. diameter. Using a variety of fuels including automotive and aviation types, gasoline and JP-4, it operates at a low 0.655 lbs. per e.s.h.p. per hr. consumption. Rugged design features and unprecedented ease of maintenance guarantee safe operation and long life.

In addition to its weight advantage as a turbo-prop, the Lycoming T-53 could be made available with front-end or rear-end power take-off or simultaneous power extraction at both ends.

There can be no doubt that the T-53 will set new standards for small aircraft. Developed by the men who built the first mass-produced jet engine to fly, Lycoming's T-53 may solve the turbo-prop problems you're facing *right now!*

To learn more about the T-53 and Lycoming's ample facilities to produce it, phone, wire or write for turbine information to Avco Lycoming, Stratford, Conn.

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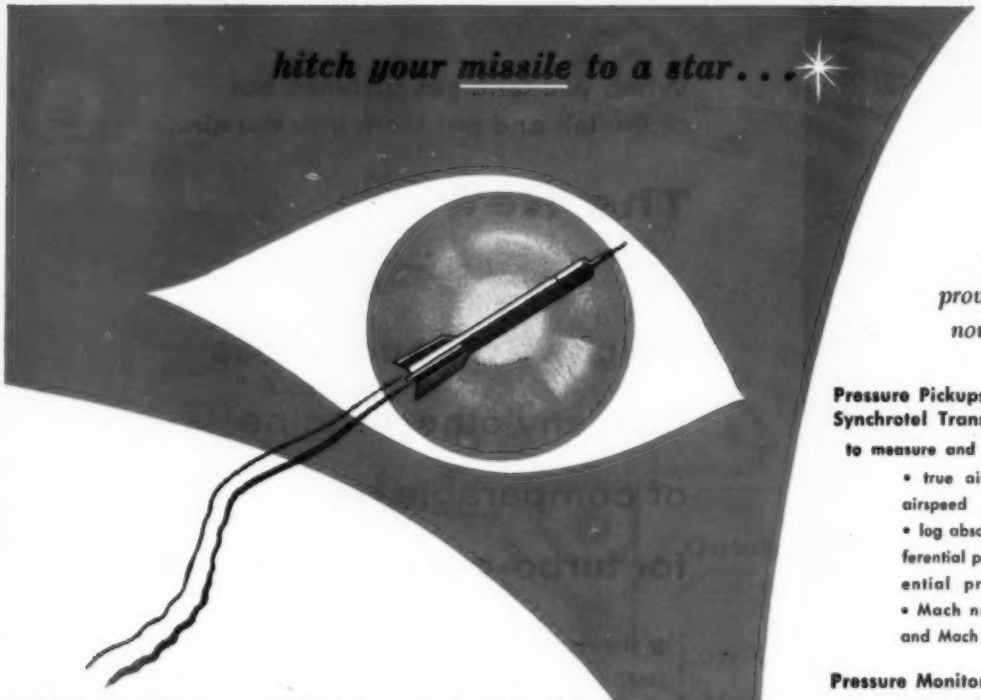

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Books

Vision—A Saga of the Sky. *By Harold Mansfield. Published by Duell, Sloan and Pearce, New York. 389 pp. Price, $5.00.*

Vision is the story of the people and events that have made Boeing Airplane Co. the nation's most successful aircraft manufacturing firm. It is a personal account, not of the management and financial background of its growth, but of the men and airplane models behind its success. And it is a story that can best be told by one man—its author Harold Mansfield—a key figure in Boeing's public relations activities for the past 19 years.

Mansfield's *Vision* traces Boeing's story from the first flight of its founder, the late William E. Boeing in 1910, to its current activities in jet bombers and missiles. It is the inside story of the planning, the test flights and the gambles of its president "Bill" Allen throughout the development of the B-17, B-29, B-47 and B-52—and most recently, the 707 jet transport. J.S.M.

Report on the Helicopter. *By Samuel C. Williams. Distributed by Stevens Institute of Technology, Hoboken, N. J. 220 pp. Price, $2.50.*

This text, the result of a year-long survey for New York investment counsellors Brundage, Story and Rose, is a handy reference volume on helicopter economics, industry history and growth. It deals primarily with the outlook for the industry through 1965 from an investment standpoint and treats such subjects as future applications, helicopter costs, potential demand, reliability and availability. J.S.M.

Aerodynamics, Propulsion, Structures. *By E. A. Bonney, M. J. Zucrow and C. W. Besser. Edited by Capt. Grayson Merrill, U.S. Navy. Published by D. Van Nostrand Co., Inc., 120 Alexander St., Princeton, N. J. 595 pp. Illustrated. Price $10.00.*

This second volume in a series on the principles of guided missile design contains a wealth of fundamental data for practicing missile engineers and students. Ten chapters are devoted to all aspects of missile aerodynamics from preliminary design to flight test, eight to missile propulsion including ramjet, turbojet and rocket power, and five to structures and design practice. J. S. M.

Britain's Aircraft. *Published by Temple Press Ltd., Bowling Green Lane, London, E. C. 1, England. Price 28¢ plus postage.*

A comprehensive illustrated listing, reprinted from *The Aeroplane*, of current British airplanes, helicopters and engines. The tabulated data form a particularly useful up-to-date reference.

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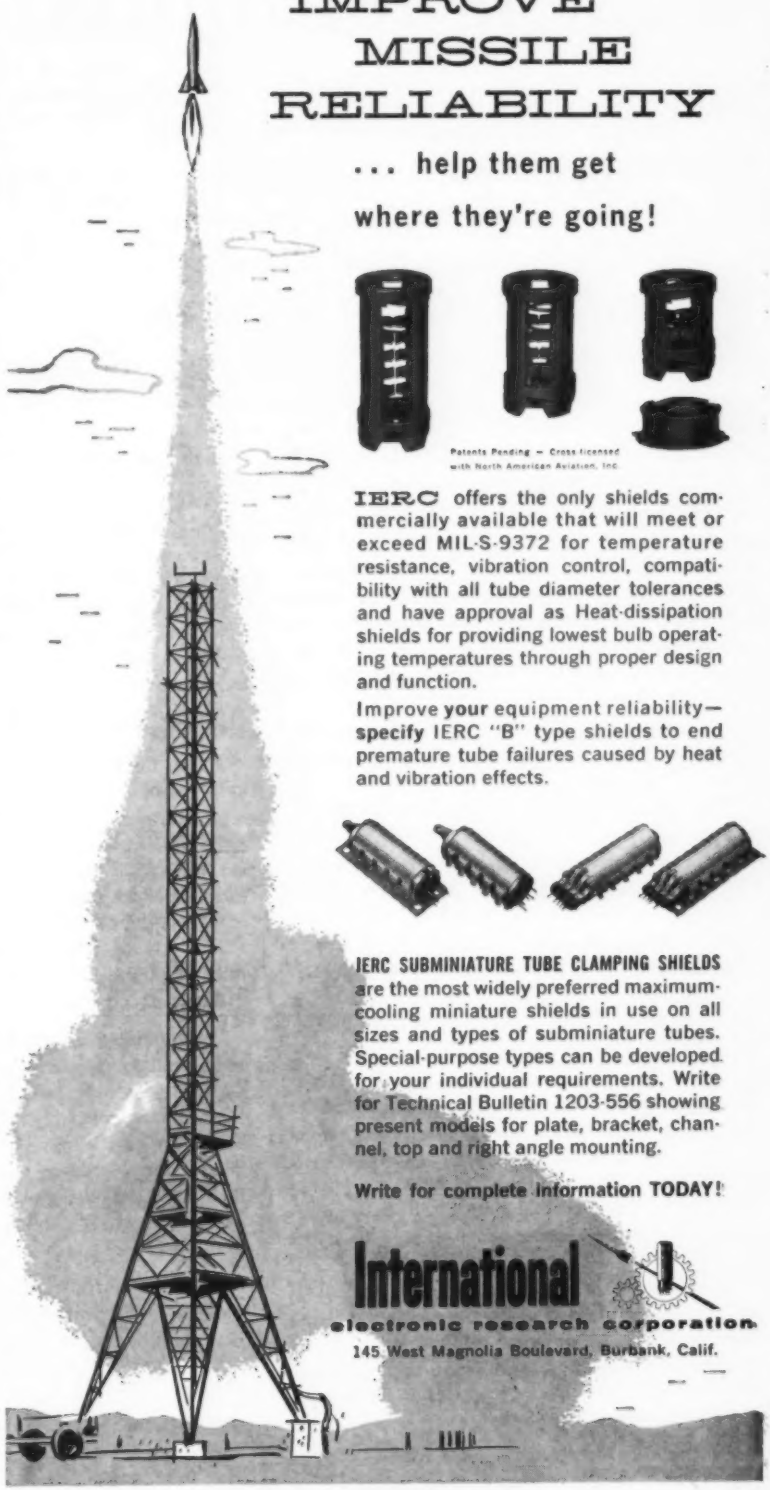

International electronic research corporation

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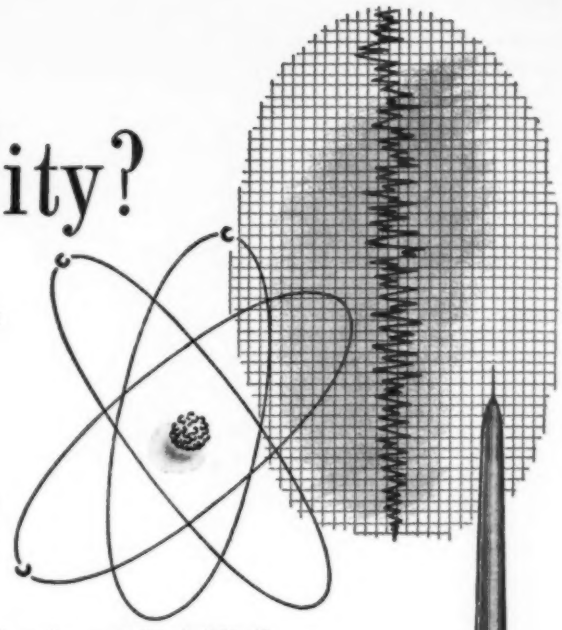
FIRST OF A SERIES

What is reliability?



Industry in the United States is becoming more and more complex... we're getting automated ... computers are computing... the missiles are flying... the digits are digitizing...

And the word "Reliability" takes a new and different meaning... what does it mean to you?

It's time to stop and take a look! Ask three of your friends how they define "reliability." You'll be surprised at the different answers you receive. And when you quiz them further on how much reliability is needed in a particular product... how they would control the design and manufacture of that product to obtain the amount of reliability they want... you'll be even more surprised by the variety of the answers.

So... let's define reliability. Let's start off with a definition that is gaining the most acceptance in the technical field...

The reliability of a particular component or system of components is the probability that it will do what it is supposed to do under operating conditions for a specified operating time.

Looks simple enough!

But what hazards it presents! The first important challenge is that word "probability"... it takes you seriously into the field of data collection and statistical analysis. Then you check into the phrase "do what it is supposed to do"... someone must define these objectives. And, look at the "operating conditions"... pause briefly and reflect on the many different conditions under which products operate. And, finally, note the phrase "for a specified operating time"... does one normally, consciously, define reliability in terms of time?

These considerations pose problems for all of us... the manufacturers of components, those who assemble components into other products, systems personnel, designers, industrial engineers, production workers, purchasing agents, quality control... *and users!*

Let's look at the word "probability."

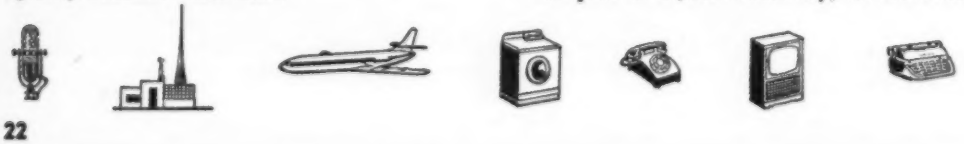
Picture a chain, with its successive links. Many of today's systems, simple or complex, comprise such a chain of components. However, as we all know, that chain will be only as reliable as its weakest link. And, statistically, the over-all reliability of the chain or system is the mathematical product of the reliabilities of the individual links expressed as...

Over-all Reliability, $R_o = r_1 \times r_2 \times r_3 \ldots r_n$

As an example, assume a product has a chain of 100 components in which each component has a reliability of 99 per cent... which assumes that only one out of a hundred units of each component will fail. These are relatively high standards established by past practices. But what happens? Multiplying .99 by itself one hundred times ($.99^{100}$), note that our chain of components will have a reliability of only 36.5 per cent! Two out of three of our chains would probably fail!

As another example, let's look at contacts in a multi-contact electric connector. If, for instance, we are to assemble connectors containing 25 similar contacts from a 1% defective contact population, we can expect 22% of the connector assemblies to contain one or more defective contacts! See how the multiplication of probabilities presents a major challenge to both designer and manufacturer?

But all is not lost! There is another side of the picture. With proper care, analysis, and control, our organization at Cannon has actually achieved, in special "missile quality" contacts, a known level of only 2.85 x 10^{-3}% defective... or one defective part in 35,000! Naturally, we don't achieve



that with all our contacts . . . but we do try to design and manufacture the utmost in reliability required for specific applications.

However, to return to your problems and to go a step further in demonstrating "probability" of uncontrolled contacts . . . and the challenges it poses to you and to us . . . consider the case where we have three groups of contacts, each group with contacts of different sizes. Let us assume, also, that each group has different percentage defective populations and that the three groups are assembled in a 90-contact connector as follows:

50 No. 16 contacts with a population reliability of .59;
25 No. 12 contacts, reliability .60; and 15 No. 8 contacts, reliability .64.

Then . . .

$$R_{c\ (90\ \text{contact connector})} = r_{\#16} \times r_{\#12} \times r_{\#8}$$

or,

$$R_{c\ (90\ \text{contact connector})} = (.59)\ (.60)\ (.64) = .23$$

It is apparent from the above that connector contact populations must be maintained at extremely low values of percentage defective. This is of extremely vital importance if we are to produce connector assemblies which will perform satisfactorily in systems utilizing series circuitry, where the failure of one contact pair can cause failure of the entire system.

We have been talking only about *a contact* . . . just one of the many different materials and parts (such as contact pins, insulators, shells, and couplings) going into the more than 20,000 different connector and electrical items we manufacture. Think of the "product of reliabilities" rule in systems comprised of tens, hundreds, or thousands of electrical components connected by connectors such as ours. Regardless of whether they design, manufacture, sell, or use washing machines or guided missiles, everyone faces the same problem. That's why we're taking some of your valuable time to present the important subject of reliability here.

*

All of us, when we specify materials, parts or components must constantly keep in mind the (a) "probabilities," (b) what the part is supposed to do, (c) the operating conditions, and (d) the time it must operate satisfactorily. Let's see what we can do to increase reliability in relation to these four factors:

(a) Probabilities. To increase the reliability of any component, and thereby the system as a whole, it is necessary to think in terms of statistical distribution of important physical properties. From field reports of failure and laboratory test results, we must first isolate those properties which most frequently cause trouble. It is then necessary to determine whether poor performance is due to lack of process control to keep the product within specified tolerance limits, whether the dollar sign has entered into the picture too far—cutting reliability down for the sake of a few cents here or there—or whether the design itself is inadequate for an end-use application. In any case, the use of the statistical approach to problem solution offers a positive method of obtaining known levels of reliability.

(b) Definition of Function of Product. Each component and each system . . . both civilian and military . . . in each different field of endeavor, in each product produced, has different functions. None of us should "overbuild" . . . nor should we "under-build." We should look at our specifications closely.

(c) Operating Conditions. Temperature and pressure, humidity, corrosive atmospheres, stray electric and magnetic fields, low and high frequency noise, shock and vibration . . . all must be considered plus conditions prior to product use.

(d) Operating Time. This varies both for different products and different fields of application. Have you set reasonable lengths of operating time for your product or system, from the viewpoints of both usage and economics?

*

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To provide a facility with which we can produce to our utmost in an efficient and pleasant environment.

To develop and produce products of such quality, and render such service, that we may always be proud of our efforts.

*

Whenever *you* have an electric connector reliability problem . . . in design, engineering, production or prototype phases . . . we would welcome the opportunity of discussing it with you.

Cordially,

Robert J. Cannon *President*

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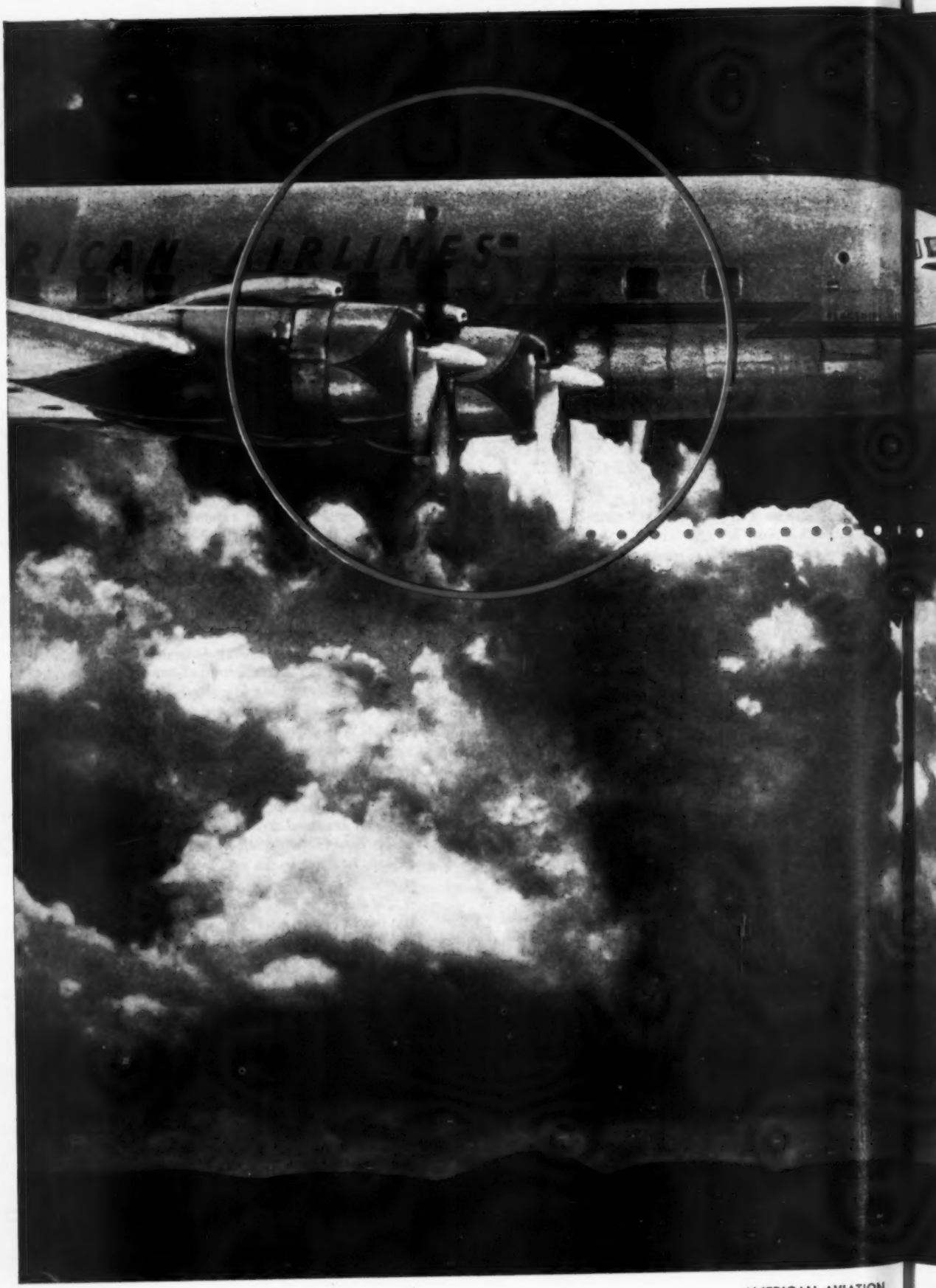

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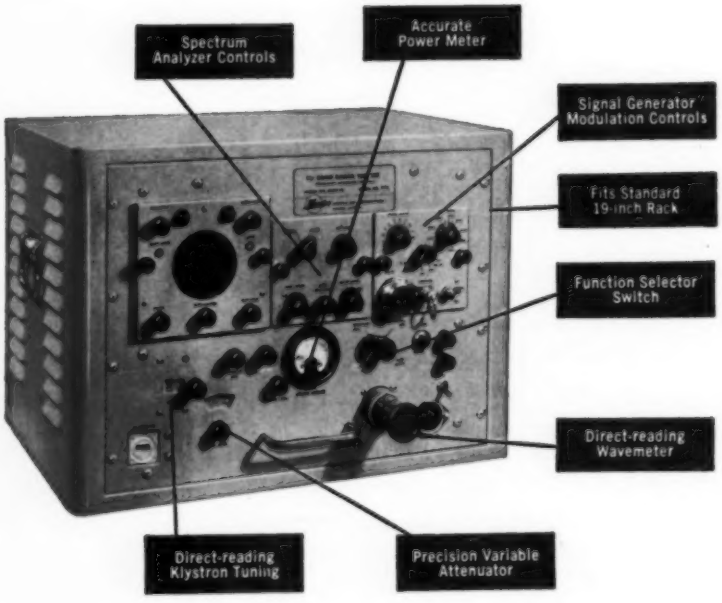

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When & Where

Oct. 22-23—Radio Technical Commission for Aeronautics fall meeting, Hotel Marrott and CAA Technical Development Center, Indianapolis.

Oct. 23-25—National Business Aircraft Association 9th annual meeting and forum, Miami, Fla.

Oct. 25-26—Second annual technical meeting on electron devices, sponsored by PGED of IRE, Shoreham Hotel, Washington, D. C.

Oct. 25-26—Aircraft Electrical Society annual display of electrical equipment, Pan-Pacific Auditorium, Los Angeles.

Oct. 29-30—Third annual East Coast Conference on Aeronautical and Navigational Electronics, sponsored by IRE, 5th Regiment Armory, Baltimore.

Oct. 29-31—Air Traffic Control Assn., first national meeting, New Colonial Hotel, Washington, D. C.

Oct. 29-31—Air Industries and Transport Assn. (Canada), annual general meeting, Chateau Frontenac, Quebec.

Oct. 30-Nov. 1—Air Transport Assn. engineering and maintenance conference, Colorado Springs.

NOVEMBER

Nov. 1-3—National Aviation Trades Association annual convention, St. Louis.

Nov. 2—National Air Taxi Conference, annual meeting, Hotel Chase, St. Louis.

Nov. 6-23—ICAO council on airport charges problems, Montreal, Canada.

Nov. 7-8—Air Transport Assn. Air Traffic Conference, Riviera Hotel, Las Vegas, Nev.

Nov. 8-9—SAE national fuels and lubricants meeting, Mayo Hotel, Tulsa, Okla.

Nov. 13—Fourth Massachusetts Aviation Conference, Hotel Statler, Boston.

Nov. 13-16—Air Transport Assn. purchasing committee, Saxony Hotel, Miami Beach.

Nov. 14-15—Aircraft Industries Association export conference, Miami Beach, Fla.

Nov. 15—Conference on control and protection of airport approaches, University of California, Berkeley.

Nov. 15-16—New England Radio-Electronics Meeting, sponsored by Boston and Connecticut section of IRE, Hotel Bradford, Boston.

Nov. 22—Tenth general assembly FITAP (independent air transport federation), London.

Nov. 25-27—Aircraft Dealers & Mfrs. Assn., twenty-eighth meeting, Drake Hotel, Chicago.

Nov. 25-30—American Rocket Society annual meeting, Henry Hudson Hotel, New York City.

Nov. 28-30—First international meeting on ozone, Chicago.

DECEMBER

Dec. 3—Flight Safety Foundation's 1956 seminar in cooperation with MATS, West Palm Beach, Fla.

Dec. 4—Air Transport Assn. board of directors, Hotel Statler, Washington, D. C.

Dec. 5—Air Transport Assn. membership meeting, Hotel Statler, Washington, D. C.

Dec. 17—Wright Memorial Dinner, Sheraton-Park Hotel, Washington, D. C.

JANUARY

Jan. 14-15—Third National Symposium on Reliability and Quality Control in Electronics, sponsored by IRE, AIEE, RETMA and ASQC, Hotel Statler, Washington, D. C.

Jan. 28-31—Eighth Annual Plant Maintenance Show, Public Auditorium, Cleveland.

FEBRUARY

Feb. 26-28—Western Joint Computer Conference, sponsored by IRE, AIEE and ACM, Hotel Statler, Los Angeles.

MARCH

Mar. 7-9—National Conference on Aviation Education, sponsored by National Aviation Education Council, Mayflower Hotel, Washington, D. C.

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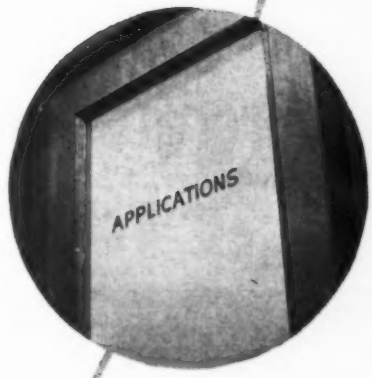

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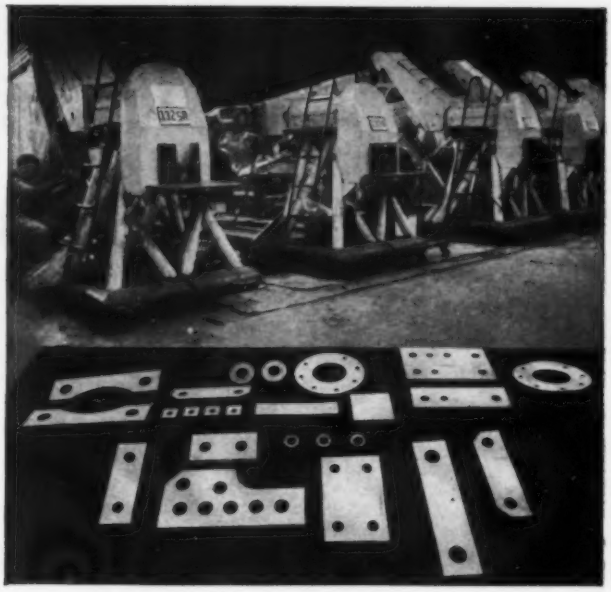

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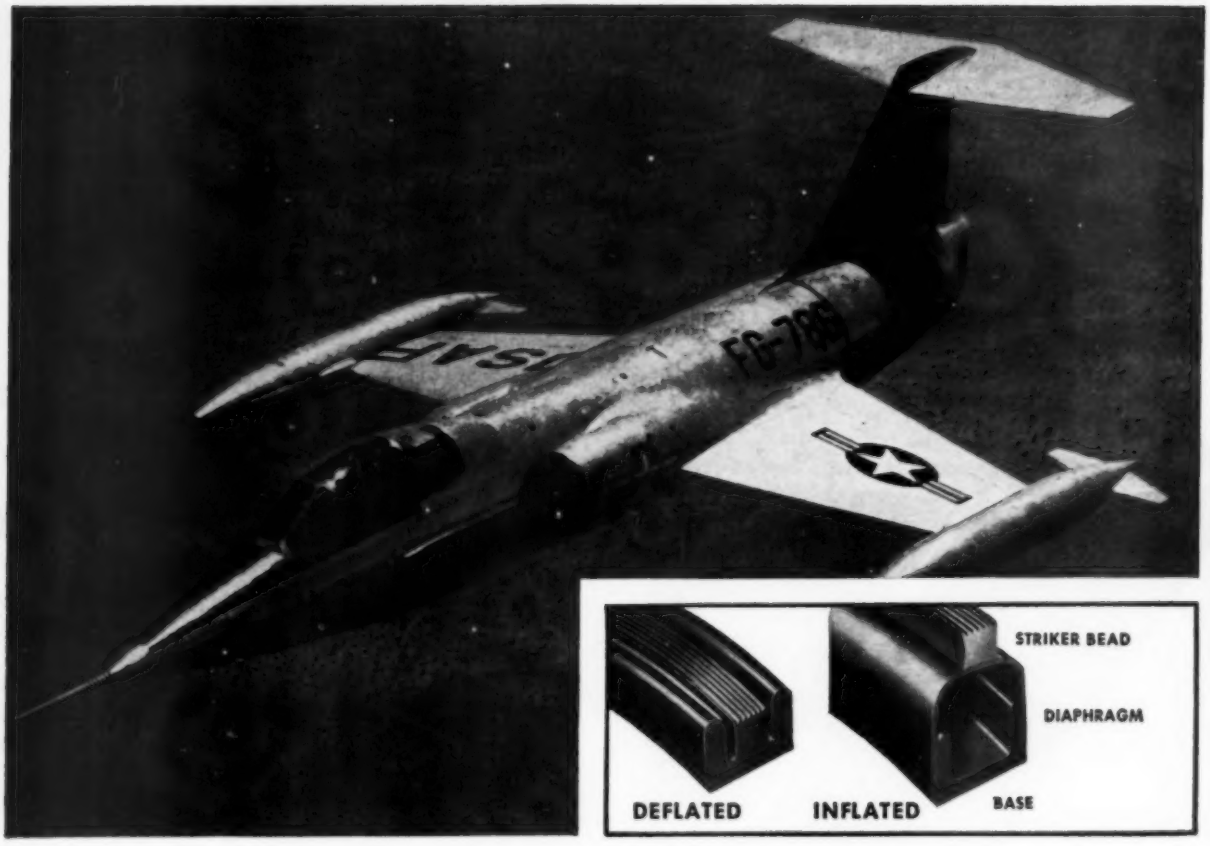

New canopy seal protects F-104 from high altitude blowouts

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ESTABLISHED JUNE 1, 1937

American Aviation

VOL. 20, No. 11

the Military Importance of RELIABILITY

By FRANK D. NEWBURY
Assistant Secretary of Defense—Applications Engineering

The combat strength of the Armed Forces depends not so much on how many aircraft, missiles, tanks and ships we have in our arsenal as it does on how much of this equipment is ready for immediate combat use. In aircraft, for example, it is not how many bombers we have in the inventory that is important, or even how many are flyable on any given day, but how many are completely ready at a given time for their total combat mission.

During the Second World War the combat readiness of the largest and most complete heavy bomber—the B-29—was largely a matter of powerplant reliability. Even though the B-29 had in it the largest complement of electronic equipment of any air combat weapon used in large quantities in the Second World War, the powerplant was the major maintenance problem.

Today the combat readiness of the modern bomber, with its more reliable jet powerplant and with the increase in the amount, the variety, and the complexity of its electronic systems, is largely a problem of the reliability and maintenance requirements of its electronic systems. Powerplant maintenance has become, relatively, a minor problem. (See page 42.)

The combat effectiveness of the whole range of our weapon and equipment systems—aircraft, missiles, ships, guns and communications—in any future war may depend on the reliability of these small components of our complex electronic systems.

The achievement of reliability of military electronic systems is a vitally important task which can be accomplished only through the coordinated efforts of the Office of the Secretary of Defense, the military departments, and most of all, through the efforts of the electronics and aviation industry. That is a measure of the importance of the accompanying article (see page 50) by James M. Bridges (Director of Electronics, Defense Department).

What AMC is Doing About Reliability

By COL. H. G. SPILLINGER*

Reliability is a factor of consideration from the time an item is a gleam in the eye of the designer until the item is discarded as obsolescent or as scrap.

Reliability is the *probability* of a device *performing* its objective adequately for the period of *time* intended, under the *operating conditions encountered.*

Spillinger

Certain words in the definition have been italicized to emphasize that reliability is concerned primarily with operating performance, time and environment. Moreover, the word "probability" denotes the importance of being able to predict the performance.

• **The objectives** of reliability are well expressed in a presentation by one electronic manufacturer who said:

•Reliability should be *inherent* in the normal *production* yield.

• Reliability should be *maintainable* under service conditions.

"Production" and "maintainable" have been italicized because of their applicability to Air Materiel Command functions. "Inherent" is italicized to highlight the fact that reliability must be present in an item before it is committed to production in quanity.

Defense Department Set-Up

Before attempting to spell out what may be termed an "AMC Reliability Program," we should look at what the Department of Defense is doing in this area. While DOD's reliability program is mainly directed towards electronic equipment, the principles are applicable to almost any other area where reliability is a must.

The program is monitored by the Advisory Group for Reliability of Electronic Equipment. The short title for this group is AGREE. The program is performed by nine "ad hoc" working committees. One research and development person and one procurement and production person from each service are assigned to each committee. The areas of responsibility of the individual committees are as follows:

• Develop minimum acceptable figures for reliability.

• Develop basic requirements for development tests.

• Develop basic requirements for pilot-production tests.

• Specify development procedures to insure required inherent reliability.

• Establish criteria for specifying reliability of components parts.

• Study *procurement* and *contracting* practices for compatibility with reliability objectives.

• Investigate *packaging* and *transportation* improvements to enhance reliability.

• Investigate effects of *storage.*

• Review operation procedures to assure maintaining inherent reliability.

Air Research and Development Command has primary interest in the first five areas while the last four bear directly on Air Materiel Command responsibilities.

Twelve Phases

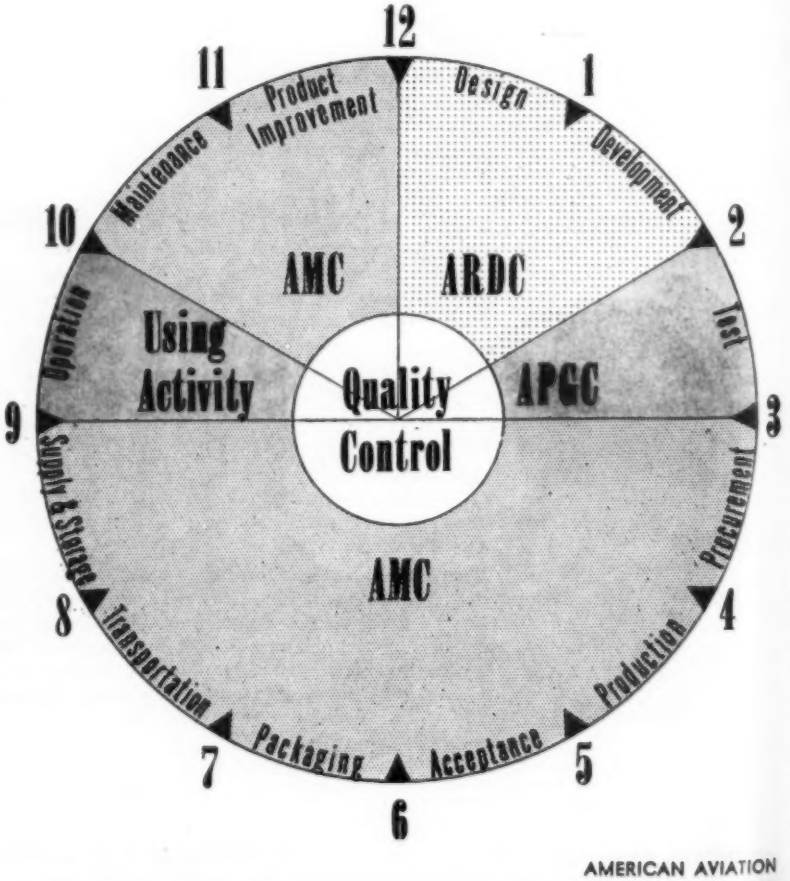
To pinpoint the part AMC and ARDC play in relation to reliability in Air Force equipment, perhaps the drawing of what might be termed the Time-Clock or Life Cycle of a product illustrates that point more clearly (see chart).

Time-Clock includes the 12 phases of design, development, test, procurement, production, acceptance, packaging, transportation, supply and storage, operation, maintenance and product improvement.

• **Design, development and test** are the responsibilities of ARDC, with Air Proving Ground Command contributing extensively in the test phase. It is in these phases that the desired inherent reliability must be "built in" before quantity production is undertaken. Operation is the responsibility of the using activity. The remaining eight phases are almost solely the province of AMC with the using activities having collateral responsibility of supply, storage and maintenance.

• **Quality control,** as a function and not as an AMC organization, is represented as the core of the product cycle, since it is through exercise of this function that we both promote and maintain reliability.

The chart shown is not meant to depict relative workload or importance but merely to illustrate the division of primary responsibilities. Anyone doing business with the Air Force should know the inter-relationships of AMC, ARDC and the using commands and realize that any such nice clean-cut delineation of function is contrary to the facts of life. There is overlap and



AMC's Reliability Program

Here's what Air Materiel Command's reliability program encompasses:

- Expansion of current AMC reliability activities within existing organizational framework.
- Work with contractors to establish time-phased reliability programs and have Quality Control and Weapon System Project Officers maintain constant surveillance of such programs.
- Have source selection activities place high value on the reliability record and proposed reliability programs of contractors evaluated.
- Collaborate with ARDC in developing specific reliability requirements for Procurement to incorporate in contracts and Quality Control to enforce.
- Emphasize reliability in AMC training programs to make personnel reliability-conscious.
- Expand Failure Reporting to cover more products and the earlier stages of product testing.

fusion throughout the cycle.

The chart shows that after ARDC has incorporated in the product as much inherent reliability as time and the state of the art will allow, AMC takes over. The part AMC plays from then on is two-fold:

- To maintain the inherent reliability of the equipment.
- To "feed-back" to ARDC and the manufacturers, failure and deficiency data—not only to improve the reliability of the item in current production, but, more importantly, to provide guidance for better reliability in future design and manufacture.

These two elements are the prime AMC responsibilities with respect to reliability.

- **Now, what is** being accomplished in these areas?

In the AMC responsibility for maintaining the inherent reliability of equipment, the principal activities involved are procurement and production, quality control, packaging and transportation, supply and storage, and maintenance.

- **Procurement** has a difficult role with respect to reliability since it is limited in action by regulations and policies which are not always compatible with reliability.

Procurement activities are assisting reliability by using the Qualified Products List to the maximum and by insuring that existing specifications which incorporate reliability requirements are contractually included.

- **Production** is contributing to reliability through having source selection include this as a factor of evaluation in contractor selection. Another contribution is evolving from the dissemination of information on new materials and better manufacturing techniques resulting from studies carried on by industry and monitored by AMC's Manufacturing Methods people of the Industrial Resources Division.

A program to obtain better control of and more specific results from the expenditure of product improvement and general engineering funds will increase reliability.

Another contribution is through tighter control of ECPs (Engineering Change Proposals) to insure that those approved will enhance and not degrade reliability.

Probably the most important contribution will result from the action accomplished through the operations of the WSPO (Weapon System Project Office).

This action requires the establishment of contractor-performed, time-phased, reliability programs of mutual acceptance to AMC and ARDC. Through Quality Control personnel and the WSPOs, these programs will receive constant surveillance. Periodic progress reports will be submitted by the contractor for analysis.

- **Quality Control** has a most important task in product reliability. The degree to which they hold the contractor to compliance with the contract provisions, applicable specifications, and acceptance tests, determines initially how much of the designed inherent reliability is retained in the product. Of course, such contractual documents must spell out reliability requirements in a measurable form.
- **The role** of Packaging and Transportation with respect to reliability is fairly obvious. Through constant testing and increased knowledge of the environmental conditions to which a product will be exposed, they are enhancing reliability by minimizing degradation from corrosion, fungus, rust, moisture, shock, and like enemies.

Likewise Supply and **Storage,** through everyday receiving, storage, issue, stock rotation, shelf-life consideration, and other similar functions, are in position to influence reliability. Constant effort is being applied to insure that the influence is good. One very important problem that Supply is concerned with is that of stock segregation, so that the proper replacement part is issued.

Maintenance Vitally Important

- **While Maintenance** has been left to last in the list of those having a responsibility to maintain the inherent reliability of Air Force equipment, it is probably the most vital. Greater reliability in equipment can materially reduce the workload of Maintenance. They are therefore devoting major effort in this direction.

In addition to establishing maintenance and overhaul procedures which keeps reliability up to par, Maintenance must also accomplish modification of in-service equipment to overcome unreliable performance.

"Feed-back" of failure and deficiency data is AMC's second important responsibility. While activities other than Maintenance can and are making contributions in this area, the effort depends on the knowledge level and initiative of individuals. The big effort is that monitored by the Maintenance Engineering Directorate and performed through the medium of what has been termed a product improvement program.

- **This program** encompasses the collection, analysis, and application of three mutually supporting sources of materiel deficiency and usage data: The Unsatisfactory Report (UR) system, the Teardown Deficiency Report (TDR) system, and the Failure Report (FR) system. The UR system has been streamlined to request corrective action on true deficiencies or one requiring special handling such as a flight safety item. The URs provide an important back-up to other failure-reporting procedures.
- **The TDR system** is a moderniza-

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* **Col. H. G. Spillinger is chief of the Production Engineering Staff Division of AMC. He's a 1925 graduate of West Point. During World War II, he served in Production Engineering, Procurement and Engineering Divisions at Wright Field. He is former Deputy for Plans, First Air Division, Okinawa; Comptroller, FEAF, Tokyo; Director of Organization and Manpower, FEAF; Comptroller, USAF Missile Test Center, Patrick AFB, Fla., and Deputy Director of Accounting, USAF Headquarters. Col. Spillinger is a graduate of the Harvard Advanced Management Course and an Associate Fellow of the Institute of Aeronautical Sciences.**

tion of the disassembly, inspection, and repair procedures used by the Air Materiel Areas to report overhaul data on powerplants. It is a narrative-type deficiency analysis report describing causes for actual or incipient failures. Extension of its use to selected Hi-Valu equipment or components will materially add to product improvement.

The most important part of the program is the Failure Report system. It has been stated authoritatively that "Reliability can be evaluated and controlled only by a comprehensive system of field-failure reporting."

Moreover, it is recognized that such a reporting system must provide for *rapid* feed-back of *statistically valid* data in a form suitable for *machine processing*. This is accomplished in the FR system. It uses short-form check-off reports prepared in the field, and submitted to the appropriate Air Materiel Area or Air Force Depot for statistical machine processing.

Machine analysis can then produce summaries of critical deficiencies in materiel and design. Currently the system is being applied to selected first-line aircraft and related support equipment. It is planned to extend it to all weapons systems throughout life cycle.

Joint Enterprise

• It is felt that expansion of these separate programs and coordination of other effort is the best approach to an overall AMC Reliability Program. It is obvious that any approach to improved reliability is a joint AMC-ARDC enterprise. ARDC must develop reliability design criteria, specify in technical requirement documents in quantitative terms the degree of reliability of minimum acceptability and incorporate contractor reliability programs in development contracts. Testing procedures must be capable of producing realistic service evaluation prior to large quantity production. Since development frequently continues into the production phase, AMC must join with ARDC in insisting that contractors establish time-phased reliability programs, that such programs receive constant surveillance and that periodic progress reports are submitted.

Insistence on industry setting up reliability programs may mean additional contractual cost and the contractor may require more facilities for environmental testing but such cost will have to be "traded-off" against the degree of reliability that is desired.

We have evidence that the cost of maintaining some of our electronic equipment through its useful life has run as high as ten times the original cost of the equipment. Obviously, money spent to increase reliability of such equipment is amply returned in decreased maintenance costs. Such costs are the ones that will have to be "traded off." However, aircraft or missiles unable to perform their missions because of unreliability of some component of equipment are a total loss. Avoidance of such circumstances makes reliability priceless. ◈◈◈

USAF Awards Lockheed $100-Million Contract

A letter of intent to award a contract valued at "well over $100 million" for additional production of the Hercules C-130 turboprop transport has been received by the Georgia Division of Lockheed Aircraft Corp. from USAF.

This is the fifth contract won by Lockheed for the assault transport, and follows an earlier award of $106 million made in May. In addition to completed planes, the new contract includes spares, ground handling equipment, engineering and technical data and mobile training units.

Douglas Test Pilot Wins Legion of Merit Award

William N. Magruder, now a test pilot for the Douglas Aircraft Co., has been awarded the Legion of Merit for outstanding service to the Air Force from July 15, 1954 to December 8, 1955, when he was a captain in the Air Force and project officer for the functional development of the B-52B weapons system.

Magruder was responsible for organizing the flight test program and during the operational phase flew more than 500 hours as aircraft commander and instructor pilot.

In two incidents involving design deficiencies in the aircraft, the citation said, he displayed exceptional airmanship in preventing service damage to the aircraft or injury to the crew and, by exceptional engineering ability, was instrumental in correcting a major deficiency in the aircraft, according to the citation.

New View of Supersonic Voodoo

This striking photo shows planform of the McDonnell RF-101A photo reconnaissance Voodoo, emphasizes low aspect ratio wing, lengthy fuselage. Powerplants are two Pratt & Whitney J57s.

WEST COAST MANUFACTURERS AGREE . . .

Reliability Improving, But Not Enough

By FRED S. HUNTER

The very fact that airplanes are flying faster and higher, round-the-clock, day or night, any kind of weather, has to be counted as valid evidence that present-day aircraft have attained a high degree of reliability.

Opinions may differ as to what is meant by high. As a matter of fact, on the overall subject of reliability and its accomplishment, there are almost as many viewpoints as there are people in the industry. But most observers will go along with Ed Heinemann, chief engineer of the Douglas Aircraft Co.'s El Segundo division, when he says: "It's getting better, but it's not good enough."

Performance is great stuff. But it compounds the reliability problem. The old airplane-engine-propeller combinations, which served our military forces well only a few years ago, were little more than kites with power compared to the labyrinths of sophisticated automatic systems which constitute our combat aircraft today. And dependable operation of complex pressurization and cooling systems, automatic fire control systems, radar systems and air refueling systems doesn't come from waving a wand.

"We went through the low point in the last series of aircraft," said C. L. (Kelly) Johnson, vice president of engineering and research for the Lockheed Aircraft Corp. "Today, we can say our airplanes are quite reliable."

• **Lockheed's new F-104A,** for example, will achieve better utilization—more flight hours per month—than the F-94C, which preceded it. That's subject to engine development, Johnson hastens to add. The qualification implies no criticism of General Electric's J79 engine, which powers the F-104A. Matter of fact, unofficial reports from Edwards Air Force Base and Palmdale hint that the latest version of this engine, the dash one, is turning out powers at altitude right according to the book.

How Delays Pile Up

But the record of experience shows it takes five to eight years to perfect an engine. Block tests provide only half the answers in measuring the performance or reliability of a new engine. It has to be flown. If it doesn't pan out in operation in the aircraft according to schedule, the delays pile up.

• **The Douglas F4D,** supersonic shipboard fighter for the Navy, is a case in point. This aircraft first flew more than five years ago, but only now is the Navy getting it into service. Meanwhile, in bringing it up to specification, it's had five different models of engines and four different fire control systems. Designed originally around the Westinghouse J40, it had to be redesigned for P&W's J57 after the J40 ran into trouble and was sidetracked by the Navy. It's a good aircraft now, but it took a lot of fixing.

Lest anyone get the idea that obvious major units such as engines, or new complications such as automatic fire control systems, make all the reliability trouble for aircraft manufacturers, Douglas' Ed Heinemann calls attention to the fact that an airplane represents the assemblage of thousands of individual products, any one of which can become a trouble spot, including the so-called "nickel and dime" items —fire warning indicators, fuel gauges, limit switches, etc.

"The fuel gauge is one of our oldest problems," observed Heinemann. "We can't have airplanes running out of fuel, but it happens."

Johnson tells of a standard switch in which two wires ran so closely together they would come together and short whenever a screw in the switch was tightened.

• **Reliability isn't** something to be developed overnight, R. C. Sebold, vice president-engineering of the Convair division of General Dynamics Corp., points out. Instead it is a continuing job of constantly hammering away at every detail of design and manufacture to be sure that all parts of the airplane work every time the plane is needed.

Convair's Methods

Sebold outlines Convair's methods of obtaining reliability as follows:

• By designing for reliability as well as performance. A component must first be able to perform its mission, but it must also be designed for efficient manufacture and maintenance.

• By constant research to find materials and methods that will do the job better.

• By manufacturing to high stan-

Air Force supersonic Century Series, either operational or in production, where reliability pays off. Top to bottom: McDonnell F-101, Convair F-102, North American F-100 and Lockheed XF-104.

dards of workmanship through a vigilant quality control program.

• By testing under all conditions of temperature, noise, pressure and acceleration to isolate potentially unreliable components for redesign before the aircraft goes into heavy production.

• By educating the customers' ground crews not only in how to maintain their aircraft to prevent failures but in how to fix, in the minimum time and for minimum money, any failures that do occur.

Sebold adds that exhaustive flight testing can also be credited with a measure of the reliability the F-102A is now beginning to demonstrate in the field. Fifty aircraft were assigned to this test program, which is still under way, and this resulted in the development of many new techniques and devices for gathering and reducing flight test data, Sebold related.

One of these devices, small enough to be attached almost anywhere within the plane, records the service history of a component. This device is still being developed and its uses extended.

Airplanes are constantly growing and becoming accustomed to new conditions. We already have supersonic fighters in the military inventory and soon the services will be dealing with speeds of Mach 2. Operational altitudes are up to 50,000 feet and going higher. New environments aggravate dependability problems.

"We don't want a 69¢ vacuum tube flying a million-dollar airplane," says Lockheed's Johnson.

• **In the main,** the aircraft industry's electronic problems as regards reliability have been in inspection and quality control. For one thing, most electronics producers were unaccustomed to the rigid standards set by the aircraft manufacturers. Their products, involving thousands of connections, were dependent upon individual skills of the workers. As one example, their processes required them to trust the soldering of the girls working at their benches. Uniformity of workmanship was difficult to attain.

Inspection and quality control procedures will be greatly simplified and reliability of the product increased as this type of work becomes automatic—now on the way. Continued development and wider use of printed circuits also will go a long way toward relieving this problem for the aircraft people, Johnson points out.

Manned Aircraft Problems

Although it's true that missile development has served to focus more attention on reliability, the manned aircraft is getting its share all along the line as witness these words from R. R. Miller, vice president and general manager of Northrop Aircraft, recently in talking before a management club group:

"It (reliability) is a basic requirement and responsibility for everyone who draws a Northrop pay check. When I say everybody, I mean everybody from Mr. Collins down to the man who learns to sweep the floor more carefully so that he doesn't get dust in a delicate black box."

It's been said that one of the reasons North American Aviation has been so signally successful in the development of military aircraft is the fact that it never quits working on an airplane, even after it is out of production. As long as it is flying it keeps striving for ways to improve it and make it a more reliable weapon. Even now it continues work on its F-86 series, although its new supersonic F-100 series is actively in service and the F-86 is nearing the end of the line. Matter of fact, North American had stopped all F-86 production, but started up again on F-86Fs to meet a new demand from Mutual Defense Assistance Pact nations. This line phases out again later this year, but North American will still have people working on the airplane.

• **An airplane fundamentally** is a carrier whether its load is in an automatic fire control system, an atomic bomb, a mapping camera, or passengers, and it is dependability of the transportation that counts in the final analysis, says Harold Adams, chief designer for the Santa Monica division of Douglas Aircraft Co.

"We may install a particular instrument which might fail in 10,000 hours of service," Adams explained. "But that instrument could make the difference between accomplishing or cancelling out a flight because of weather or some other flight condition, say every 2,000 hours.

Thus in the increased sophistication of our product we may have to consider that we lessen our particular aircraft's reliability to the extent of one additional component failure in each 10,000 hours of flight. But we will be making our transportation more reliable by making five schedules that otherwise would have been cancelled.

"In other words, we trade one flight for five, or a gain of four. Certainly this will be the way to measure reliability for an airplane like our new DC-8 jet transport because dependability of the transportation is what is apparent to the passenger."

Unceasing Quest

• **The quest** for improved reliability in commercial transport aircraft is unceasing. A transport must be efficient and economical in order to earn a profit, and the airplane must not become obsolete before its capital investment has been amortized.

Approximately 50,000 original drawings and changes are stored in Engineering Records at Douglas Santa Monica for the DC-6/7 series. In the transition from the Model 749 Constellation to the Model 1049 Super Constellation, Lockheed engineers worked out more than 550 design improvements as a direct result of airline operating experience and 360 of these were maintenance items. Simpler maintenance is a

Lockheed Tells AF It Would Like to Take Over Maintenance of Military Aircraft

Lockheed Aircraft Corp. has submitted a proposal to the Air Force for a revolutionary experiment in the maintenance of military aircraft.

This is to take over aircraft maintenance from the Air Force and assume the responsibility for keeping the aircraft flying under a contract. Servicing in the field is included.

Lockheed's objective in proposing to take the crew chief out of uniform and put him on a factory payroll is to improve maintenance efficiency, which is now so serious a problem in the military services because of the technical personnel shortage.

Factory pay scales run higher than the military, but Lockheed feels such an arrangement would be more economical in the long run because of better learning curves, less turnover, more expert workmanship. But the big point is that the Air Force could depend on having airplanes ready to fly. The contract would include penalty clauses.

If there's a war, Lockheed's workers would don uniforms—perhaps like the Air Transport Command in World War II—but they would continue on Lockheed's payroll and Lockheed would still be responsible for maintenance of the aircraft.

Lockheed is reported to have submitted the proposal for one of its aircraft models and one of its missile models. Neither has been identified, but the airplane undoubtedly is the F-104A and the missile probably is the X-7 ramjet.

Air Force is reported studying the proposal.

direct pathway to reduced down-time, greater utilization.

"An airplane that can't accomplish eight hours utilization is no good; 10 hours is about right; some airlines make 12," says Lockheed's Kelly Johnson.

Payload ratios of forthcoming transports won't be as good as those for present planes, but they'll make more money for the airlines through greater utilization. Passengers will be pleased by their improved schedule dependability as well as their improved performance.

• **You pay** in weight for reliability and maintainability, Johnson points out. Perhaps, Johnson hints, future commercial transport engines should be different from military engines because of this. Add weight for better engines. Improve endurance. Reduce unscheduled engine changes. "You can make a case for it," Johnson observes.

Douglas Experience Cited

Earlier this year—in June—the Douglas Aircraft Co.'s newest and largest transport was placed in service by Pan American World Airways on its Atlantic division. This was the DC-7C. The new plane went into service with a background of DC-6/7 series experience totalling 6,593,459 flying hours, imposing mathematical testimony to the reliability of the 1956 brand of transport.

The following is a breakdown of these flying hours according to model: DC-6, 3,577,731; DC-6A, 223,735; DC-6B, 1,866,205; DC-7, 490,079; R6D-1 (Navy), 261,171; C-118A (Air Force), 174,538.

As of this compilation, American Airlines had a DC-6 which had logged 27,373 hours and a DC-6B with 16,504 hours. National Airlines had put 8,373 hours on a DC-7. Nearly 100 DC-6s are around the 25,000-hour mark. Forty-six DC-7s had passed 6,000 flying hours.

• **Douglas service department records** show that combined airline utilization of DC-6/7 aircraft (domestic and foreign) averages between eight and nine hours a day. The leaders in utilization: DC-6s, American Airlines, 10.30 hours; DC-6Bs, Australian National Airways, 12.51 hours; DC-7s, Pan American, 10.19 hours.

Many factors have contributed to the Douglas company's success with the DC-6/7 series, says chief project engineer J. R. McGowen. One in particular has been extreme flexibility in design, tooling and manufacture.

"This has resulted in a steady day-by-day improvement of the airplane together with occasional timely major improvements," said McGowen. "The sequence of these major improvements have fitted together neatly to provide a steady flow of competitive aircraft of steadily improving range, payload, speed and comfort."

A good deal of pioneering is going on now in the aircraft manufacturing industry.

Bold steps are being taken in the the transport field with new designs such as the Boeing 707, Convair 880, Douglas DC-8 and Lockheed Electra.

The military is performing feats of scientific magic with supersonic fighters such as Chance Vought's F8U and Douglas' F4D for the Navy, the Air Force's century series—North American F-100, McDonnell F-101, Convair F-102 and Lockheed F-104—and near-supersonic bombers, like the Boeing B-47 and B-52 and the Douglas A3D, and striving impatiently for breaks through to new frontiers of even faster, higher flight.

Pioneering is always vulnerable to the unknown and this leads to the question of whether we may be pushing ahead of the state of the art in our race for technological progress. That's where philosophies of reliability and performance clash.

"Are we becoming Mach happy?" asks Ed Heinemann reflectively. "Should we adopt a more philosophical viewpoint and say to ourselves, 'Ah yes, it is engineering-wise possible, but is it practicable?' Just could be."

Keep your eye on the down-time curve. ◈◈◈

Dayton Firm Launches Full Production Of Fast-Starting Cold Weather System

United Aircraft Products, Inc. of Dayton, O. has signaled the start of large-scale production of its new deaerating cold-weather oil system, a design tailored to speed aircraft and ground equipment starts in sub-zero Arctic temperatures.

Coupled with the company's hot fuel prime system, it permits piston engine starts in less than two minutes and a takeoff within 30 minutes, compared to previous six to 12-hour requirements.

Air Force acceptance of the two systems followed cold-weather field and flight tests at Ladd AFB, Alaska; Churchill, Canada, and Thule, Greenland. In all, UAP estimates it has spent about $500,000 and 8,000 engineering manhours in research, development and field tests.

However, despite its extensive private financing of both development and production, company officials are convinced the gamble has been well justified.

Today UAP is furnishing the deaerating cold-weather oil system to eight airframe manufacturers and airline operators both as original equipment as well as for retrofitting existing aircraft and ground equipment.

• **Here's how** the two systems operate:

• Hot fuel priming system—This system supplies hot fuel to the engine at 220°F in two minutes, despite outdoor exposure to "cold soaking" at —65° temperatures.

Fuel is routed from the main tank-to-engine fuel line through a hot fuel prime tank, the priming solenoid valve and into the carburetor via the priming nozzles.

Total system weight is about 10 lbs., 7.79 lbs. for a tank heating element containing Calrod heaters and 2.4 lbs. for a 400-amp, heater relay.

• Deaerating cold-weather oil system—This 12-pound installation is made up of two components—a special hopper installed inside the engine oil tank and a diverter-segregator valve that controls the flow of oil as temperatures dictate.

DCWOS dispenses with the need for external preheat sources and uses only heat rejected by the engine to bring oil flow and temperature up to normal within 30 minutes. This compares with four hours preheat often required in the past—an operation that called for elaborate and expensive external heat sources.

• **At engine starting,** the diverter-segregator valve controls flow so that oil is supplied to the engine directly from the hopper and return oil from the engine is routed only to the hopper. As engine heat raises oil temperature to 130°F, the valve opens the main oil tank port and allows oil flow from the engine into the tank proper.

Later, as engine oil temperature reaches 160°F, the diverter valve provides a full open tank port while the hopper port is nearly closed.

However, it maintains a small quantity of oil flow through the hopper continuously to prevent entrance of air at the tank outlet.

Although new, DCWOS is by no means an unproven system, company officials point out. To date it has been adopted as standard equipment on Piasecki H-21 helicopters, Grumman SA-16 and Fairchild C-123 aircraft. In all, they figure it is now seeing everyday service on more than 300 single and multi-engine planes in all-weather operations. ◈◈◈

New Engines Pose Wide Variety of Problems

By JAMES HAY STEVENS

LONDON—This is the period of the birth of the third-generation aviation gas turbine, of the emergence of the practical rocket and ramjet, and of the naissance of the problematical nuclear airplane engine.

None of these, incidentally, entirely eliminates the reciprocating engine, which still seems to have many years of useful life ahead—particularly in the smaller sizes.

The revolution which came in the midst of World War II, when Heinkel and Whittle flew their experimental turbojet aircraft, has so far progressed in three distinct stages.

• **First** came the low-pressure ratio turbojet; the short-life German axials made from non-strategic materials and the more conservative British centrifugal-flow engines based on Whittle's thinking. The centrifugals gave reliability to the new propulsion medium during the early years while the airplane designers were finding just how to use all this extra power —and where to put it.

• **Second stage** was perfecting the first batch of axial-flow turbojets by overcoming such problems as blade aerodynamics, resonance and manufacture. These troubles were sorted out in time to curtail the advancement of the centrifugal compressor beyond a single stage.

While the axial compressor still is not entirely free from surge and other troubles, it does now offer the only practical combination of high thrust with low frontal area. This second stage already has been refined virtually to its limit and new solutions are being sought in several directions.

It is here that the crossroads can be seen. It seems unlikely that all the many suggested directions of development can prove successful—or that the finance will continue to be forthcoming for them all.

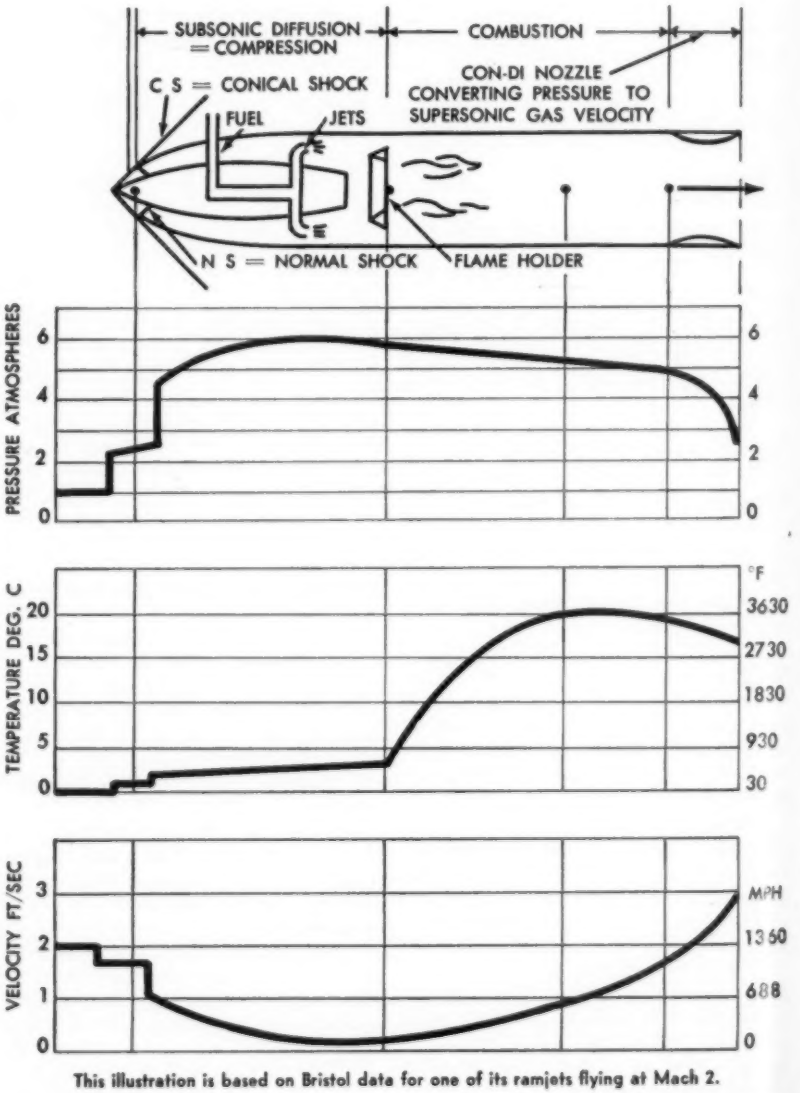
• **The first split** is between the turboprop and the purejet. The turboprop has, in the past decade, been offered by world-renowned authorities as first a half-way stage between pistons and jets, then as a powerplant in its own right, next as the answer for range-flying, then for economy at 500 mph. Now there is even talk in Connecticut of the supersonic 800 mph turboprop.

There exists, too, the anomaly of the U.S. military services adopting the turboprop as the only means of combining high payload and extreme range with good cruising speed—and the airlines scorning economy in favor of speed.

• **The second division** is between very high pressure ratio and large mass flow. High pressure ratios (10 to 1 and upward), as in all internal combustion engines, offer fuel economy—specifics of three-quarters of a pound for a pound of thrust, four-fifths of a pound for one horsepower.

These engines, however, choke themselves to death above Mach 1, even in the 70-below stratosphere, but heating up their air so much that little fuel can be added for combustion without exceeding turbine temperature limits. Supersonically, above 1,000 mph (Mach 1.5 in the stratosphere) a low or moderate pressure ratio becomes essential.

The engine to give this must have large air-swallowing capabilities and a few, coarse-acting, axial stages to accelerate up to Mach 2, after which the afterburner comes into its own with high thrust at reasonable economy.



This illustration is based on Bristol data for one of its ramjets flying at Mach 2.

To date, three supersonic turbojet philosophies have been offered:

• Simple low-pressure ratio—De Havilland Gyron (and Junior).

• Variable-blade compressor—General Electric J79.

• Medium p/r two-spool—Orenda Iroquois.

All, be it noted, use afterburners as the prime thrust producer above Mach 2.

The big catch is to obtain propulsive and thermal efficiencies high enough over the whole speed spectrum to insure consumptions that will not make it impossible for the airplane to carry the fuel for the job.

However the power may be provided, a fighter airplane traveling at Mach 2.5 will be using the equivalent of nearly a quarter of a million horsepower.

This, in turn, indicates a fantastic rate of fuel consumption and the airplane designer must make a choice between a power complex offering efficiency over the whole range or he must optimize on supersonic performance, in which case the airplane will be climbed supersonically to operating height so as to minimize flight time. That is, literally to beat the clock by racing to complete the mission before the fuel gives out.

Whatever way you look at it, the answer to the problem lies in the "dual powerplant"—even a multiple one—and so it is a question of what the compromise shall be and of where the line should be drawn for each individual specification. Whether to have a dual-purpose engine or dual power is the basic question.

• **First feature** to note is that with the adoption of the afterburner as a component part of the engine—it is integral in the J79 and the Iroquois and, although not shown with the Gyron, D-H thinking tacitly considers it as an essential adjunct—the turbojet has become a dual-purpose powerplant.

This means that it is two engines in one; a turbojet subsonically, with a ramjet cutting in supersonically or as an uneconomical power booster at lower speeds. Even so, at Mach 2.5, the air leaves any but a very moderate ratio compressor at "cherry-red" heat—around 900°F—which limits the fuel-burning capabilities just when the power need is greatest.

To meet this it is obviously desirable to be able to exchange pressure ratio for mass flow, which is exactly what General Electric does with the variable-incidence compressor stator of the J79. Orenda Engines, with the Iroquois, has taken another line by splitting the compressor, so that its characteristics can be readily varied to match different performance envelopes simply by changing the discs.

The first is analogous to the variable- and the second to the adjustable-pitch propeller.

• **The De Havilland** principle is to keep the turbojet as simple as possible, but to introduce a third factor to the complex—a rocket. (Whether D-H Engines makes the Spectre rocket because of its fighter philosophy, or whether it evolved the philosophy because it had a good development rocket, is not easy to assess.)

The thinking here is that the rocket is required anyway to give an operational performance above, say 50,000 ft., so why not bring it right into the picture instead of leaving it on the fringe as a mere ceiling booster? This, D-H has done, and explained publicly by diagram.

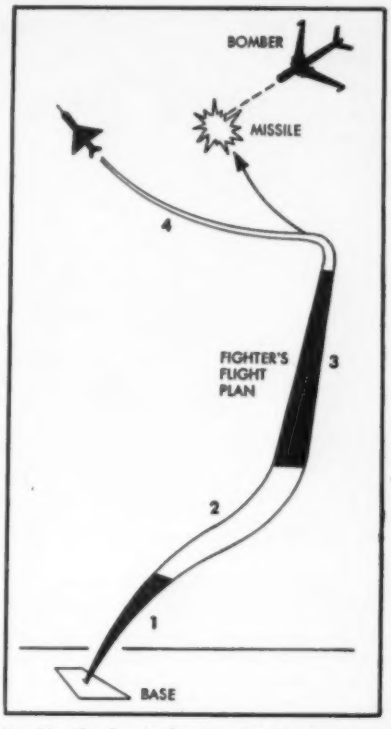
• **French thinking,** in the Sud-Ouest Aviation Trident, with its trichamber SEPR rocket and Armstrong Siddeley Viper tipjets, leans to a straight division of duties between rockets (supersonic speed, altitude, climb) and turbojets (subsonic cruise).

The Marcel Dassault MD 550 delta interceptor is similarly powered. The English Saunders-Roe interceptor, now nearing the flight stage, was originally planned on a similar scope to the French, but seems to have crystallized more closely along D-H lines.

The Pure Jets

The possibilities of the rocket—and its severe limitations—were demonstrated back in 1944 by the Messerschmitt Me 163 employed by the despairing Luftwaffe against the U.S. Eighth Air Force. High speed and acceleration are unaffected by altitude, but endurance is drastically curtailed by the bulk and weight of oxygen carried.

These are the basic design factors, unaffected by the great strides in rocket techniques, that have made the motors lighter, longer lasting, more reliable and throttleable—*but* the fuel/oxygen ratio for chemical combustion is an unalterable fact of physics.

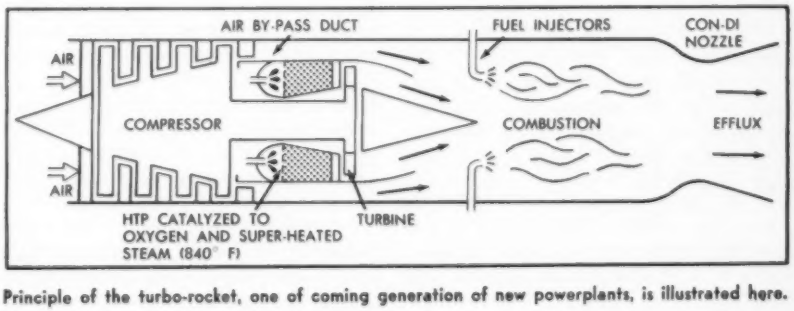


De Havilland mixed-power interceptor concept involves using: (1) Gyron turbojet with afterburner for take-off and initial climb; (2) Gyron with afterburner plus Spectre rocket to maintain climb to operative height and accelerate to supersonic speed; (3) Gyron with afterburner to maintain speed; (4) Gyron with afterburner for manoeuver, attack and escape. The Gyron alone is used for economic cruise back to base.

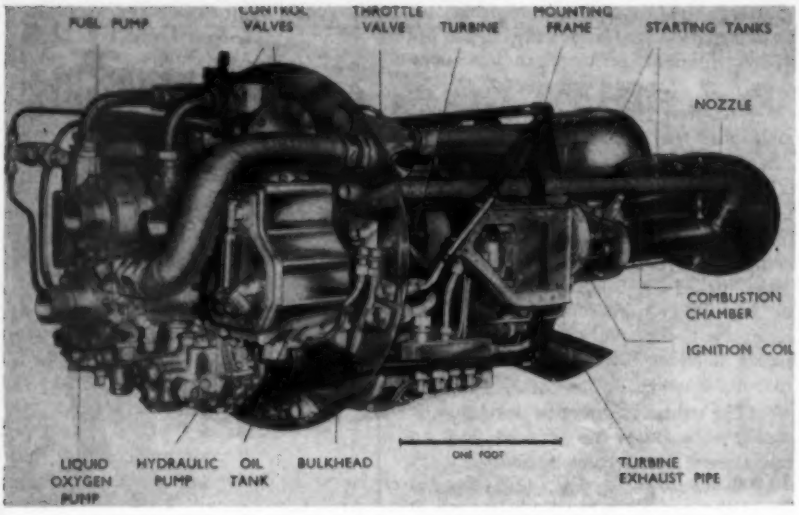
To quote an example for one high-thrust airplane rocket for which data is unclassified, the Armstrong Siddeley Screamer LOX/kerosene unit gives 9,500 lbs. thrust and would consume 44 1/3 short tons of propellant in one hour. This is equivalent to 9.33 lb./lb.t./hr., as against 0.7 to 0.9 lb./lb.t./hr. of kerosene for the high-pressure ratio turbojet and, perhaps, 1.1 lb./lb./t./hr. of the low-pressure one.

• **Efforts are being made** to achieve a compromise between the rocket's high-altitude performance and the turbojet's economy—the turbo-rocket, as being developed by Aerojet General.

The idea here is to use what oxy-



Principle of the turbo-rocket, one of coming generation of new powerplants, is illustrated here.



One of Britain's most important rocket motors, the Armstrong-Siddeley Screamer.

gen exists in the varified upper atmosphere and to boost it with an internal supply, at the same time releasing some of the energy in the oxydant for internal power drive. That is, by catalyzing a liquid such as hydrogen peroxide, its internal energy is released as superheated steam (as with the D-H Sprite ATO rocket or the various helicopter rotortip rockets) to drive a turbine.

This turbine then activates a compressor which supplies air along a by-pass duct that is mixed with the oxygen released from the HTP, the whole being burned with fuel. It is, in fact, a by-pass engine in which the internal "boiler" cycle is independent of atmospheric air.

• **The resulting engine,** in theory, at any rate, ought to be able to top the ceiling of the plain ramjet, since the compressor would gather together the widely-spaced oxygen molecules at very high altitude, and it could well lift the limit of air-breathing engines above 100,000 ft.

Drawings have been published suggesting that combustion would take place before the turbine (with later afterburning) but this writer has a hunch that the low resistance of air at the heights envisaged would require compressor power that could be satisfied by simple catalysis.

It is, of course, likely that the usual hydrocarbon fuel will be replaced by something less subject to altitude effects, such as aluminum-trimethyl, diborane, or powdered magnesium—but that is a trend for all very high-altitude combustion engines.

The Ramjet

The ramjet offers a stage between the afterburner-turbojet and the rocket: compact, light, simple, it gives considerable ceiling improvement over the turbojet with far lower fuel consumption than the rocket.

A 16-in. diameter ramjet flying at Mach 3 at sea level could develop the equivalent of 90,000 hp with the help of its high ram pressure—ideally 37 atmospheres—which also offers economy comparable with a turbojet.

The ramjet is, of course, a hot engine, since it is largely an uncovered flame tube, and requires its own installational outlook. It forms, however, a very neat pod which offers little drag as a "passenger" should it not be cut in below its optimum operating range.

The low installed weight of the ramjet implements its generally favorable high-altitude flight characteristics and it is generally held to be operational at Mach 2 up to 80,000 ft., and at Mach 3 up to 100,000 ft.—whereas 70,000 ft. is the generally accepted limit for the turbojet.

• **Big drawback** of the ramjet is its poor subsonic specific fuel consumption and total absence of thrust below about 200 mph. René Leduc has faced up to this in his integral/ramjet 022 fighter by mounting a 7,000-lb.-thrust turbojet for takeoff, cruise and landing power. Since this single small jet would take a long time to accelerate and to climb, Leduc foresees the interception flight pattern as cutting in the ramjet early and climbing supersonically all the way.

The Leduc ramjet is controlled by shutting down some of the concentric rings of burners, so reducing power and overall fuel consumption—although the specific will actually be worse when running throttled.

• **Another French idea** is the turboramjet of the SNCA du Nord, which Jean Galtier expects to mount in his Griffon delta interceptor early next year. This is, in effect a by-pass turbojet designed to feed the afterburner with more air than just the unburned portion of the turbine efflux.

A secondary drawback with the ramjet is the problem of accessory power where there is no rotating shaft. In missiles, this is currently solved by tapping ram air and diffusing it into turbines that drive fuel or hydraulic pumps—the latter, in turn, feeding hydraulic motors which drive electrical generators.

The limitations of ram-air power packs are that they provide little or nothing at low flight speeds. This is of no consequence with missiles, but it means that a reliable additional power takeoff must be supplied for airplanes intended to be landed back at base. (It may be recalled that the non-throttleable Me-163 interceptor was brought in with a dead stick and relied on a windmill generator for its ancillary services).

Multiple Power: Pilot's Problem

Several intriguing statements have been published on the advantages of multiple-powered fighters, but nobody, to the writer's knowledge, has stated the pilot's case.

It is no mean feat today to flight-plan the climb/speed/cruise vs. normal/afterburner fuel, so as to make it last—to spread some three tons of kerosene over a 30-min. flight.

• **Peter Twiss,** when setting up the 1,132 mph. world speed record in the Fairey F.D.2., had to use his afterburner just long enough to climb to height and to accelerate for each of the two runs, actually cutting it before the timing course—to go faster was easy, but to return would have been impossible.

This, too, was a carefully flight-planned mission, not a come-as-you-go interception. Working it out with three variables—turbojet/afterburner/rocket—scarcely warrants serious consideration. Although it may be as computable as a collision course, there must be occasions where the human pilot will have to judge to within seconds how many minutes he can run each engine.

Nuclear Power

Billions of dollars are being spent on the nuclear reactor programs intended to give global possibilities to bombers and the first units are within sight of flight.

The writer feels that the nuclear reactor airplane engine, while undoubtedly feasible, is basically and fundamentally unsuited to airborne requirements. Primarily, the weakness lies in the highly-concentrated weight of shielding, which, even on a "shadow" basis, must be provided.

This means a large aircraft, at least 250,000 lbs. gross, although the fuel for several weeks of continuous flight would weigh but a few pounds. Maximum landing weight will—apart from any bombs dropped—be identical with that at takeoff. This means much stronger and heavier landing gear than today.

• **However,** militarily, it is always essential to keep up with the Joneses and such airplanes will certainly see service—both sides of the Iron Curtain. Parking, servicing and, above all, crash hazards present radiation problems that become more involved as one thinks about them.

Not a few technicians in the U.K. are seriously considering an orbital nuclear transport. This would be a very large airliner, flying continuously on a nonstop schedule with a course well clear of populous centers, to and from which passengers, freight and provisions would be ferried in flight, the airliner landing only every month or two at a remote base for servicing and change of fuel!

If this sounds fantastic, one only has to recall the USAF's success with releasing and "recapturing" fighters under the B-36.

• **The conversion** of nuclear energy into propulsive thrust offers extremely difficult problems in heat transfer, some form of ducted fan appearing the most hopeful mechanical device. Recently released German work by Dr. H. J. Kaeppeler suggests, however, that there may be a possibility of using nuclear energy more directly.

The suggestion here is to use nuclear-decay batteries composed either of radio isotopes with short half lives to emit a stream of beta-rays, and hence electrons, or to convert the electromagnetic radiation of gamma rays into beta rays.

In both cases, an intensely hot arc (9,000°F) would be produced which could be used in a short, compact ramjet. The nuclear-decay battery should be far less of an installational, weight and radiation problem than the nuclear reactor and could well provide a power package for comparatively small airplanes.

Also on a physics note is the USAF Holloman Base suggestion of using a catalyst to re-combine the dissociated oxygen and nitrogen atoms of the upper atmosphere. Re-combination of the atoms to air molecules would recover a large quantity of heat energy that could well be used in a ramjet.

Air Transport Propulsion

There is considerable talk in the U.K. of the supersonic airliner—with some bitter argument. Whether practical or not, it is obviously a long way off at a time when no country can fly one man at a time for as long as half an hour at 1,000 mph.

The immediate thinking on the airliner's powerplant rests on the decision between the turbojet, the turboprop, or the by-pass to achieve range and payload. In all three, greatly improved specifics have made them practical competitors with the fully-developed Turbo Compound piston engine.

• **In each,** speed has compensated in part for greater fuel consumption—aided by cooperative air traffic control giving flight clearance and landing priority—and speed and quiet have also proved to be highly salable commodities.

The improved specifics are the result, primarily, of the solution of the problems of high-pressure ratio axial compressors. Surge has generally been suppressed by adopting the two-spool configuration which, given equal design expertness, is considered to make the lightest and most reliable compression, despite the co-axial shafting.

A secondary trend, which is more debatable, is whether to run the turbine hot or cool. A cool turbine is a low-stressed one, however you look at it, but the hotter the combustion gases the more energy there is available for extraction.

The current tendency is to run internal cycles, particularly for turboprop and by-pass, as hot as possible, thereby carrying the minimum of unproductive cooling air. The power turbine then extracts the heat energy from the efflux.

New materials, such as the recently declassified Nimonic 100, enable turbines to approach 1,800°F for the first time, while hollow-blade air cooling, aided by new turbine disc alloys, will shortly raise the limit above 2,000°F.

• **Ultimately,** as MATS policy asserts, the large turboprop can lift more fuel and make it go farther than any other present-day engine. Whether, when speed and utilization are considered, this would represent airline economy is a complex question with the experts in abusive disagreement.

Advantages of By-Pass

The by-pass turbojet, because of its better aerodynamic form and the absence of propeller slipstream offers higher speed with the advantages of the hot internal cycle. At first, this was expected to offer specifics between those of a turboprop and a straight turbojet, but in any event it is generally found more profitable to use the higher efficiency mainly to make the engine smaller for a given power.

Lufthansa, when stipulating Rolls-Royce Conways for its Boeing 707 fleet, quoted an extra 6,500 lbs. payload gained for its extreme-range route. Absence of any cooling drag and a maximum engine skin temperature of 212°F play their part in making the Conway installation light.

• **The by-pass** is generally deemed a subsonic powerplant, but there seems no technical reason why it should not come in again supersonically (above the unprofitable Mach 0.9-1.7 range) where its large proportion of unburned air should be ideal for afterburning.

If this be so, then the rivalry between the turbojet and the by-pass may be perpetuated in the future. In this connection, it is only fair to realize that the whole reputation and future of the by-pass rests on the expertness of one company and in the performance of one engine—albeit in numerous forms.

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KB-50 All Lit Up for Refueling

KB-50 Superfortresses, modified as tankers by Hayes Aircraft Corp., have been fitted with a battery of spotlights for night refueling operations. Rotating beacon atop vertical stabilizer aids jet pilots in spotting the tanker. Refueling stations, at fuselage tail and pods under wingtips, are equipped with probe-and-drogue hoses.

What's Ahead in Field of Jet Fuels

By AUBREY KEIF
Manager, Aviation Sales
The Texas Company

In the early days of what has been aptly called "the jet adventure," the effort to interest British investors in Frank Whittle's project to develop a gas turbine aircraft engine got a critical boost from Sir Henry Tizard, then Rector of Imperial College, London, and chairman of the official Aeronautical Research Committee.

In a letter to Lancelot Law Whyte, the eminent Scotch scientist-philosopher who was guiding the financing of the turbine project, Tizard said of Whittle, ". . . I think it highly probable that, if he has the necessary financial support and encouragement, he will succeed in producing a new type of power plant for aircraft."

Whyte, in his published recollections of the great difficulties in getting Flight-Lieutenant—now Sir Frank—Whittle's scheme into the practical development stage, says the Tizard letter "transformed the situation, for it meant we had the support of the highest opinion outside the government . . ."

Elsewhere in his letter Sir Henry said, " . . . the fact that such an engine would use heavy oil is of great importance from the point of view of defense and of commerce."

Thus, it can be seen that the question of fuel has been of central importance from the initial phase of the development of the first aircraft gas turbine in its present form. When Whyte and Whittle first met on September 11, 1935—five years after Whittle had filed his first turbine patent applications—the engineer-designer described for the scientist the "great jet planes that in ten or twenty years would be speeding around the globe at incredible heights."

It is improbable that Tizard could have reckoned that two decades later, as we prepare to cross the threshold of Whittle's dream, the fuel question would be the subject of a wide-ranging, and still unconcluded, debate.

The subject of jet fuel was bound to provoke a variety of comment and opinions for it impinges on the interests of all the parties contributing to the impending arrival of jet flight on a broad scale on domestic and world airlines. Aircraft engine manufacturers, airframe manufacturers, airline operators, airport management, and petroleum refiners all share a vital concern in the selection, manufacture, distribution, storage, handling and utilization of jet fuel in civil flight.

All aviation interests are aware that extraordinary problems are involved in the question of *what's ahead in jet fuels.* All have a great stake in the progress of the next era of flight and all are preparing to solve vexing problems in relation to fuel.

I should like to suggest that present differences of opinion tend to obscure a basic point: the problems arising in the various segments of the industry are inter-related and their common solution is interdependent.

In the past, each segment of the industry has enjoyed some measure of success as a result of the contributions of all to the solution of technical problems. Therefore, there is every reason to believe that the present disagreements will be constructively resolved by combined effort. The goal of all, of course, is to provide the safest, the finest and most economical air travel possible.

• **We are not far off** from Whittle's timetable. Some turboprop airliners are already in service. There are now on order 726 turbine-powered aircraft that will go into service on continental and inter-continental airlines during the next five years. These orders form the basic profile for projection on commercial jet flight for the next half decade.

The advent of large-scale commercial turbine aircraft flight coming on top of growing requirements for military jet fuel will have a considerable impact on the petroleum industry.

In estimating what changes are in store, it is well to start with this fact: initially, the jet engine will arrive in service gradually. It will not replace the reciprocating piston engine overnight. Far from it. For a number of years it will supplement piston engines. It must be remembered that piston engines will be earning revenue for airlines for many years to come.

In the near future the large majority of the commercial aircraft census will be piston-powered. To estimate the numbers involved, you would have to analyze all piston aircraft now flying from the standpoint of obsolescence resulting from changing competitive conditions and then off-set the numbers which may be retired from major airline service in the next half decade, or so, by the present orders for new piston airplanes. These now number 300. New orders for replacement will tend to maintain this offset for an indeterminate period.

• **Thus it can be seen** that the petroleum industry will continue its responsibility for providing a large volume of aviation gasoline for some time. It would appear that the demand for avgas will continue to increase through 1960, the peak demand will be about 240,000 barrels per day. It will then decline gradually through 1965.

The avgas pool will continue to be improved and the petroleum industry will be committed to considerable capital spending for research and processing facilities for about another decade. As an index to quality improvement in avgas, it has been estimated that more than half of that to be consumed in 1965 will be above the 100/130 grade.

While accommodating this increase in the quantity and quality of avgas, the petroleum industry will also be assimilating the initial impact of commercial jet fuel demand. Today, jet fuel demand—military and civil—is already overtaking avgas requirements.

The coincidence of increased demand for avgas and a tremendous growth in jet fuel requirements will create a complicated situation in the petroleum industry. Aside from the obvious magnitude of the processing problems, there will arise unusual problems in handling the several products. In some degree these will be shared by airport operators and the airlines.

Separate systems of distribution, storage and local handling will have to be developed and maintained. One

example will suffice to illustrate what airport management faces. At peak traffic periods, a major airport may have to fuel four or more jet airlines at the same time. Simple arithmetic reveals that over four tank cars of jet fuel will have to be pumped into waiting aircraft in less than thirty minutes. And, of course, storage levels will have to be maintained.

It might be useful at this point to remark on the fact that the lubricating oil picture, as regards volume, will show a change in the other direction. Less oil will be used in lubricating jet engines than is used in piston engines. It has been disclosed by one airline that the Rolls Royce Dart turbine engine, now in airline service in the Viscount, uses in the order of 0.08 pints of oil per hour in flight.

• **It is apparent** that fueling jet airliners is going to be big-volume business for the oil companies. The size of the business for which they will compete is indicated in fuel consumption projections for two aircraft. The Douglas DC-8 will consume about 2,000 gallons of fuel per hour in its turbines. By comparison, the DC-7 uses about 450 to 500 gallons of avgas an hour. The Boeing 707 will cruise at 550-600 mph, carry 124 first-class or 146 tourist passengers and will also burn about 2,000 gallons of turbine fuel an hour. It will have fuel capacity of 21,200 gallons on the domestic version and 23,600 gallons for the inter-continental type.

Based on 3,000 hours' use per year, the foregoing turbine fuel hourly consumption figures represent an annual consumption per jet aircraft of this size of 6 million gallons. Piston aircraft of comparable size average about 1.5 million gallons of avgas annually.

Therefore, the petroleum industry has in prospect a yearly jet fuel requirement for 1959-1960 of about 1.2 billion gallons. This can be compared with the 987 million gallons of fuel consumed by U.S. airlines in 1954. (The jet fuel figure is for all turbine aircraft now on order.)

Tentative Specifications

The present consumption projections necessarily refer to a question-mark jet fuel. As of this writing a committee of the American Society for Testing Materials has drawn up sets of tentative jet fuel specifications. These are shown in the accompanying table.

There are tentative specifications for both of the basic types of aircraft gas turbine fuels: the kerosene, and the JP types. ASTM membership is presently studying the specifications and will vote on them. These tentative specifications do not as yet constitute an ASTM recommendation. They do, however, represent a cooperative step toward the resolution of the technical aspects of the fuel question.

ASTM D-2 Technical Committee "J" Proposed Aircraft Turbine Fuel Specifications

(Note—subject to change. These specifications have not yet been approved by ASTM)

	Turbine Fuel "A" (Kerosene Type)	Turbine Fuel "B" (JP-4 Type)
Gravity °API	39 — 51	45 — 57
Flash °F. Tag Closed Cup	110 or Legal — 150	—
Heating Value:		(Note 1)
Net BTU per pound (Estimated)	18,400 min.	18,400 min.
BTU per gallon (Estimated)	121,500 — 126,500	117,500 — 122,500
Smoke Point mm, min.	20	(Note 3)
Lamp Burning Test D-187	—	—
16 Hours (See Note 2)	Pass (Note 5)	—
Smoke Volatility Index	—	54.0 min.
Aromatics Content—Total	20 max.	23 max.
Olefins Vol %	—	5.0
Thermal Stability CFR Coker Test (Formerly Erdco Coker Test) (Note 4)	300 — 400°F; 5 hrs.; 6 lbs.; 12" Hg pressure drop; Light stain max.	300 — 400°F; 5 hrs.; 6 lbs.; 12" Hg pressure drop; Light stain max.
Freezing Point °F.	— 40 max.	— 60 max.
Pour Point °F.	— 40 max.	—
Viscosity Kin @ —30°F.	15 c.s. max.	—
Existent Gum Mg/100 Ml.	7 max.	7 max.
Potential Gum Mg/100 Ml.	14 max.	14 max.
Sulfur Wt. % total	0.3 max.	0.3 max.
Mercaptan Sulphur Wt. %	0.003 max.	0.003 max.
Water Tolerance Ml Vol change	1 max.	1 max.
Copper Strip corr @ 122°F.	1 max.	1 max.
Distillation		
IBP °F.	—	(Note 3)
10% °F.	400 max.	(Note 3)
20% °F.	—	290 max.
50% °F.	450 max.	350 max.
90% °F.	—	470 max.
F. B. P. °F.	550 max.	(Note 3)
Residue, 5	1.5	1.5
Loss, %	1.5	1.5
% Evap. @ 400°F.	—	(Note 3)
R. V. P. p.s.i.*	—	3 max.
Oxidation Inhibitor	Optional	Optional
Corrosion Inhibitor	Optional	Optional
Metal Deactivator	Optional	Optional

Note 1. Type B Fuel Aniline—Gravity product of 5250 Min. acceptable as alternate for net BTU/# Value.
Note 2. Lamp Burning Test not required if Smoke Point 25 MM, Min. or above.
Note 3. To be reported, not limited.
Note 4. This test method will be prepared for publication by ASTM. CRC have method now.
Note 5. Must meet requirements of VV-K-211c specification for kerosene.
** Reid Vapor, Pressure p.s.i.*

It has been apparent that certain petroleum products once considered possibilities are not suitable for jet fuels. For example, residuals and even heavy distillate fuels have not proved acceptable. Their performance characteristics do not recommend them.

• **Avgas has also been eliminated** from consideration as a normal jet fuel for commercial aircraft. Turbine aircraft operating at reasonably high altitudes might have to have a rather high degree of fuel tank pressurization to accommodate the high vapor pressure of aviation gasolines.

Other inherent factors cancel out the operating utility of avgas. For example, the presence of tetraethyl lead would markedly reduce engine overhaul periods and might cut down engine life. Further, the cost of avgas today and in the foreseeable future would make it unattractive to airline manage-

ment. (It costs more per gallon and per pound.)

However, avgas could be used for emergencies for short periods. It is, of course, widely available. Its emergency use would impose certain flight restrictions such as reduced rate of climb, operating altitude, and duration of engine overhaul periods. Military use of avgas in turbine engines is another matter which involves different criteria in economics, operation and maintenance.

The kerosene type of turbine fuel is presently in use in turboprop airliners and many airlines have indicated that they will prefer it. It has certain over-all economic advantages. However, these have been threatened by restrictive specifications.

Freezing Point Considerations

The freezing point of commercial kerosene turbine fuel involves two considerations. First and foremost is that of availability. Lowering the freezing point has a critical effect on the availability of a suitable fraction for use as a commercial jet fuel. On the other hand, a freezing point that is too high would necessitate the use of heating equipment, or other means of assuring adequate flow of the fuel to the engine.

If a restrictive freezing point specification is established, the adequate availability of kerosene fuel could be accomplished only as a result of additional processing or selection of fractions. This would increase the cost of the fuel and thus minimize the economic incentive for the use of kerosene to fuel commercial jet power plants.

The present JP type of fuel—JP-4—is, like kerosene, now in use in commercial turboprop airliners. It is sometimes called a "wide-range gasoline." It contains gasoline and heavier fractions, utilizing a wide range of distillates. A typical aviation gasoline has an initial boiling point of about 110°F and a final boiling point of about 310°F. In comparison, a typical JP-4 fuel has initial and final boiling points of 120°F and 550°F.

As currently used in military aircraft, JP-4 has specifications which have been drawn to both logistical and operating requirements. It can, as a result, be manufactured in far greater volume in time of war.

As has already been indicated in the instance of heating fuel to maintain pumpability, the airframe manufacturer faces new problems in the era of jet flight. Fuel weight is a critical problem. The weight of an aircraft at take-off may be twice its weight at landing. The difference will be the weight of the fuel burned in flight. A great volume of tankage must be designed into the airframe. Today, there is a growing awareness that the engine, the fuel and the airframe have to be carefully integrated as components of flight.

• **Finally, the fuel question** arrives at the desks of airline management. This is where all other considerations encounter the profit-and-loss statements of daily operations. The pressure of airline economics will certainly weigh heavily in the final resolution of the question. Empty seats on a giant jet airliner may persuade against the technically perfect fuel which keeps passenger-mile unit costs too high.

The best fuel for the rapid growth of jet flight, with sold-out jet liners coursing the country's and the world's airlanes, will be that fuel which first assures passenger safety and then most economically combines the requirements of all concerned. Operation on a non-restrictive kerosene-type of fuel appears to have more desirable factors than operation on another type.

However, this implies that the refiner can manufacture a fuel slightly different from that now in use, that the engine manufacturer can adapt his engine to the fuel, that the airframe manufacturer can provide in his design for the use of fuels with marginal freezing points, and that airline management can operate its aircraft at maximum fuel efficiency versus the conditions of the flight route.

In his first conversation with Lancelot Law Whyte, in 1935, Sir Frank Whittle tempered his optimism with the native caution of a good engineer. The 28-year-old inventor had five years of disillusionment behind him—he had let his patent applications lapse for want of funds. He gave Whyte a realistic estimate of the possibilities of success; the odds, he said, were 50 to 1 against him. It is unlikely that 20 years later we cannot come up with the right fuel now that the 50 chances against jet flight have long since been disposed of. ◈◈◈

Here's Exide Program to Insure Airline Battery Reliability

Reliability in commercial airline transport operation means two things—maximum passenger safety and on-time performance. And both demand unfailing performance, not only of the basic airplane and its engines, but of every component and accessory on which their systems depend for operation.

To get these results, airlines have turned to comprehensive maintenance programs, sometimes on a flight-to-flight basis, others daily, and still others every hundred, thousand or more hours of operation.

A case in point is the attention given by Pan American World Airways to just one factor of aircraft electrical system operation—the battery. PAA's fleet and spare needs call for 500 to 600 aircraft batteries, and at anywhere from $25 to $75 per copy, this represents an investment of $25,000 to $30,000.

• **To make sure** its aircraft electrical supply has an adequate, dependable battery reserve power and, at the same time, protect this investment, PAA checks batteries before, during and after each flight. In addition, they are removed regularly for testing and servicing in the maintenance shop.

With engines off, both the technical group and flight group check battery voltages before and after each flight. If a battery tests less than a specified safe voltage, it is replaced.

After every flight, electricians check electrolyte levels and, if needed, add water to battery cells. If the top of a battery is wet, it is replaced and sent to the battery shop. Electricians test, service plane's voltage regulator.

In flight, the flight engineer period-

Ratings of Exide Aircraft Batteries

Type	Charge Rate Amperes	5-Hour A. H.	5-Hour Amps.	20 Min. Amps.
3-TAS-9B	3.0	34.0	6.8	54
6-TAS-9B	3.0	34.0	6.8	54
6-TS-9F	2.0	24.0	4.8	36
6-FH-13	7.5	90.0	18.0	145
12-TAS-11	3.5	42.0	8.4	67
12-TAS-13F	4.0	51.0	10.2	81
AN-3150-2 (12-TS-11N)	3.0	36.0	7.2	70
AN-3151-2 (12-SHP-9A)	2.0	24.0	4.8	43
AN-3152-A (6-TS-11N)	3.0	36.0	7.2	70
AN-3154-1A (12-AC-9H)	1.0	11.5	2.3	20
D-6A (6-TAS-17)	6.0	68.0	13.6	108

ically checks the generator voltage and adjusts it to keep the battery ready for peak performance. All PAA transports have 28-volt electrical systems and generator regulator settings are maintained at approximately 28.2 to 28.4 volts.

Every two months, all batteries are removed for discharge tests and servicing in a terminal battery shop. To assure removal of the battery at the proper time, the due date of the next discharge test is painted on the end. Results of the last test also are shown to indicate approximate condition of the battery.

• **Pan American's** maintenance program is an example of the type of procedure recommended by manufacturers to assure long-life performance of batteries in all types of aviation service.

On the basis of the experience of its service engineers who help airlines and other plane users with battery problems, one manufacturer—Exide Industrial Division of The Electric Storage Battery Co.—has come up with its recommendations for a practical maintenance program.

Exide's aviation battery maintenance recommendations are based on the fundamental needs of keeping batteries at or near full charge, of adding water, and of keeping batteries clean and dry.

• **Because aviation batteries** are small in relation to connected loads and generator ratings, two important precautions are emphasized:

• Adjust voltage regulators carefully to avoid overcharging.

• When using batteries to supply the plane's electrical load while engines are off or generators are disconnected, avoid overdischarging.

Test the specific gravity of the batteries after each flight—once a day if flights are short or infrequent. If a hydrometer reading is below 1.240 or the open circuit battery voltage is less than 24 volts, remove the battery for recharging and testing.

• **Whenever a battery** is removed from a plane, check the adjustment of the regulator. Also, check the voltage regulator if the battery is uncomfortably warm to the hand, whether or not the battery is removed from the plane. Voltage regulators should be set at an approximate open circuit voltage of 28.5. Check and adjust voltage level of regulators during flight.

The terminal maintenance shop should report to the battery shop the reason for removal of a battery.

First step in the battery shop is to check electrolyte level. If necessary, fill cells with approved water to about ⅜ inch above the protector on top of the separators.

• **The next step** is to fully charge the battery at the ampere rate recommended by the manufacturer. Exide aircraft battery ratings, shown in the table, are typical. Terminate the charge when three successive hourly gravity readings of the lowest reported gravity reading cell and its voltage show no increase.

Mechanic removes battery cover for pre-flight check.

Battery is removed for return to terminal shop.

Flight engineer re-checks battery for safe voltage.

Record both gravity and voltage readings. Do not exceed the recommended charge rate at end of charge. It should be no less than 80 per cent of the value shown when readings are taken.

Temperature readings may be taken but the experienced maintenance man usually can determine, by putting his hand on the battery, whether or not it is within a range of 70°F and 100°F. Use a fan to cool the battery, if necessary.

Just before stopping the charge, read and record battery voltage. The battery is serviceable if it tests more than an average of 2.40 volts per cell. Hence, a 12-cell battery should test above 28.8 volts; a 6-cell battery, above 14.4 volts; a 3-cell battery, above 7.2 volts. Replace batteries testing lower than these values.

If the specific gravity of the electrolyte of a serviceable battery is below 1.250, adjust it upward. To adjust, fully charge the battery.

With a syringe, remove the low-reading electrolyte above the cells. Replace it with 1.300 electrolyte, charge for an hour to mix and read gravity again. If gravity still is low, remove electrolyte again, and repeat as necessary. Do not adjust gravity above 1.290.

Optional Method

• **An optional method** of testing battery serviceability is to determine its electrical capacity by discharge test. The battery first must be fully charged, and the specific gravity of the electrolyte adjusted, if necessary, to 1.285. Discharge the battery at the 20-minute rate given in the table for 16 minutes or until battery voltage drops below 1.50 volts per cell average, whichever occurs first. At an average of 1.50 volts per cell, a 12-cell battery will read 18.0 volts; a 6-cell battery, 9.0 volts; a 3-cell battery, 4.5 volts.

Batteries testing at more than 80% of capacity are serviceable. Therefore, if the battery delivers the 20-minute rate for 16 minutes before reaching the above voltage, it is serviceable. When the test is completed, fully recharge the battery.

Before it is returned to service, wash the top of the battery with water, vent plugs in place. Also, give the battery an external physical inspection to be sure there are no damaged parts which might cause it to fail.

Exide officials contend that such simple maintenance procedures, carefully and regularly followed, pay real dividends in terms of battery life and performance. To the airlines, such a program is a basic safety precaution, and one that spells reliability of aircraft electrical system operation. ◈◈◈

Sound Design: Basic Ingredient of Reliability

By J. M. BRIDGES

Director of Electronics, Office of the Assistant Secretary of Defense—Applications Engineering

The necessity for improving the reliability of electronic equipments and systems in order to obtain an improved status of combat effectiveness has been recognized for many years by those engaged in the various phases of military planning, development, production, maintenance and operation.

Only during the past year or two, however, have the specific causes of unreliability been sufficiently well understood to permit an evaluation of their relative contribution.

For a long time, the generally accepted belief throughout industry and the military was that unreliable electronic equipment resulted primarily from system complexity, poor component parts and tubes, and low-quality manufacturing. Consequently, the effects of poor or incomplete design upon reliability usually were not recognized or, at least, were not adequately emphasized.

Now, as a result of the extensive study of the reliability problem which has been made by various agencies of the Defense Department and industry during the past few years, it is recognized generally that the reliability of an electronic equipment in service depends more upon the quality and thoroughness of its design than upon any other single factor.

• **Of course,** good design of itself cannot assure that an equipment will have satisfactory reliability in service. If available tubes and components parts are not good enough, even when used correctly, to meet the reliability requirements of an equipment design, the reliability of the end product will be limited. In addition, even if the design of an equipment is excellent and all tubes and parts are of a satisfactory quality, the equipment's reliability in service may be unsatisfactory owing to poor manufacturing methods and processes. The importance to reliability of these various factors not associated with design is recognized, and programs are under way within the Defense Department to bring about improvements in these areas.

Two Major Aspects

Since sound and completed design is so essential to the reliability of all equipments and systems, this phase is receiving the greatest emphasis in the extensive reliability improvement effort being directed by Secretary Newbury's office.

BRIDGES

• **There are two major aspects** to the problem of attaining better design for reliability in military electronic equipment and systems. The first is technical in nature and involves the detailed engineering principles of design; the other involves various phases of program planning and management having a significant bearing upon design.

The engineering principles of good design for reliability are becoming fairly well known and are now being applied effectively by some design agencies, but unfortunately they are not being widely used throughout industry. It may be worthwhile to mention some of the more significant engineering principles related to reliable equipment design that have been most commonly neglected. These are:

• The design of circuits in a manner which takes full account, on a statistical basis, of the long-time variations in characteristics and uniformity of all component parts and electron tubes, to assure continued proper operation of the equipment in its service environment. The reliability of many equipments now in service suffers from critical circuits which will work satisfactorily only with tubes and components "selected" for particular ranges within their specified operating characteristics. Obviously these equipments will not function satisfactorily when the characteristics of these tubes or components change with age or when replacements are made with tubes or components which are outside of the "selected" operating ranges.

• The proper selection of electron-tube types and component parts to assure compatibility with the required environmental conditions and equipment reliability requirements. This requires that the tubes or parts selected not only meet the JAN specifications and have the proper initial characteristics for their intended use, but that their long-time variations in characteristics and their expected life match the equipment requirements. If existing military specifications do not adequately describe life characteristics, tests of these characteristics should be required by the equipment contractor.

• The design of circuits and mechanical assemblies to provide for operation of all components and tubes well under their rated operating limits. Particular emphasis should be placed upon the temperature, shock and vibration to which tubes and electromechanical components are subjected.

• The design of mechanical and electrical features to facilitate maintenance.

Outline Being Prepared

Because of the importance of these and other broad design philosophies to equipment reliability, their inclusion in developmental contracts is considered desirable. To this end a document which will outline the major developmental procedures for insuring inherent equipment reliability is presently under preparation as a part of the current activity of the Advisory Group on Reliability of Electronic Equipment under the direction of the Office of the Assistant Secretary of Defense (Applications Engineering). This material, which will be available for distribution in a few months, will be in a form suitable for inclusion in development specifications.

• **The other major aspect** of the problem of obtaining improved design is related to program planning and management; it is less tangible than the matter of detailed design but fully as important. The rest of this article will be devoted to these planning and management factors.

The first of these is the establishment of the time schedule for the design work. Many of the design deficiencies resulting in unsatisfactory equipment reliability are due to the allocation to a program's development phase of insufficient time to permit the accomplishment of a thorough design job.

Obviously time scale is a very important factor in the entire defense effort, and every reasonable step must be taken to keep developmental time cycles to a minimum. It should be realized, however, that the trading of quality and effectiveness of weapons and weapons systems for a shorter time

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scale, or the adoption of design short cuts, may result in a very small, if any, net gain to national defense.

The schedule for a design job should be established on a realistic basis jointly by the military agency and the contractor who has been selected to do the development work. Actually, in many cases promised completion dates have been a significant, or even controlling, factor in the selection of a development contractor. This has often resulted in the proposal of unrealistic program schedules and, ultimately, in the short-cutting of design by the selected contractor.

It must be recognized that the extra time invested in design should be offset by a reduction in the time required to establish quantity production and to make the necessary "in-production" design changes so that the item will be acceptable for service use. Not only does poor or incomplete design resulting from a hurried time scale adversely affect the efficiency of weapons and weapons systems, but it is poor economy as well.

• **The second** program-management factor affecting the quality of design is the selection of the contractor to do the development work. The proper design of a complex and intricate item of military electronic equipment is an extremely difficult task. It is seldom done well by a contractor that is not qualified in the specialized field involved nor by one who offers his services at "bargain basement" prices.

Special Talents Required

There are many different specialties in the weapon electronics field, and they require different specialized engineering talents. A contractor may be very competent and have a record for doing excellent design work in one of these specialized areas, yet he may do a very poor job in another area. Every electronics company, big or small, cannot be expected to possess the diversified talents and experience required to do a good design job on all types of military electronic devices.

In selecting a contractor for design work, demonstrated capability in the specialized field involved and an earnest desire to do a thorough engineering job are far more important to the best interests of the government than estimated cost. If electronic equipment design is bought at "cut-rate" prices, it is probable that the resulting equipment will have second- or third-rate quality and reliability.

• **Another major management factor** having a significant influence on the quality of design is the establishment of firm requirements for evaluation of the design prior to quantity production for service use. Without a doubt, one of the greatest causes of unreliability in military electronic equipment has been the introduction into quantity production of a new design before adequate tests and evaluation have been made to determine its suitability for manufacture for service use and before major design deficiencies have been determined and corrected.

This situation is related to the continued demand for shortening the time cycle from idea to service availability of new weapons or equipment. In special cases, a certain amount of risk is justified in committing a new weapon to production for service use in advance of a thorough evaluation of the adequacy of the design. The justification for such a risk depends upon many factors, including the urgency of the need for the new weapon or system, the degree of confidence in the design contractor and the amount of untried technology involved.

Unfortunately, however, premature production has been the rule rather than the exception and very often has been resorted to with little or no justification. It turns out in most instances that little or no time is saved by premature production of a newly developed weapon. A few months may be saved in getting the first item off the production line, but this amount of time, or more, may be lost in production delays required to remedy design deficiencies which seriously impede production or to make the equipment acceptable to the user.

• **Experience has shown** that several kinds of evaluation are necessary for a sound determination of the suitability of a new design for service use and its readiness for quantity production.

The first of these is a technical evaluation involving the determination by engineering tests of the ability of the design to meet the technical performance requirements and to establish the suitability of its mechanical and electrical design from the standpoint of circuit design, selection and application of components, and maintainability.

It is also required that the operational suitability of the equipment or system design be determined by an actual check of equipment or system performance either in a service or simulated service operational and maintenance environment.

Producibility Problem

Another essential evaluation relates to the producibility of the design. Many military programs have run into rough weather because large-scale production contracts have been let for design coming directly from the developmental laboratory without any real test of producibility.

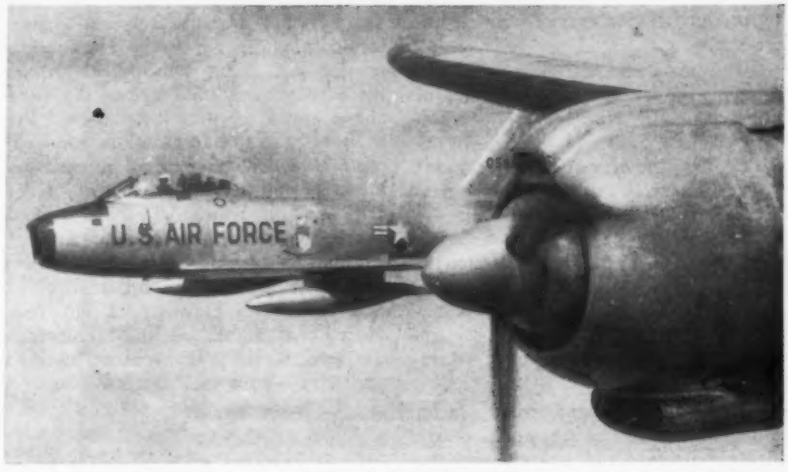
The evaluation of producibility should be based on actual pilot manufacture of limited quantities of a new item, using production methods and representative tooling. This pilot-production phase of design evaluation serves several purposes:

• It verifies the producibility of the design, including the accuracy and adequacy of the manufacturing drawings and specifications.

• It provides sufficient numbers of the new item to permit a realistic determination of performance and reliability.

• It permits the determination and

F-86 Paces TWA Super-G in Tests



An Air Force F-86 paces a TWA Super-G Constellation during recent tests to determine proper methods of installing altimeter and airspeed indicators in high-speed jet transports. Specially calibrated recorders in Sabre were used to check out Super Connie instruments.

correction of design deficiencies affecting producibility or reliability before quantity production for service use is undertaken.

Because of the vital importance to reliability of design completion and of design evaluation, the Secretary of Defense on July 5, issued a directive requiring that these evaluations be made by the military departments before new electronic systems and equipment are approved for service use. This directive, No. 3222.1, represents a major step in the program being directed by the Assistant Secretary of Defense for Applications Engineering to improve the reliability of military electronic equipment.

• **The final management factor** having a direct bearing upon design quality relates to the attitude and understanding of contractor management. It is absolutely essential to the attainment of good design and final equipment reliability that the management of the company doing a military electronic equipment or system development job understand thoroughly the importance of equipment reliability to the defense effort and the national economy.

Good Communications Needed

To assure that adequate support is given to the engineers doing the actual design work, this understanding and appreciation of the vital importance of good design to equipment reliability must exist through all echelons of company management from president to project engineer.

I am sure that if top management in industry were aware that the quality of design being accomplished in some remote corner of their engineering department could materially influence the effectiveness of an important weapon or weapons system, and consequently the defense of the country, they would see to it personally that the engineers were doing the best possible job they knew how to do.

This management attitude and understanding must be established not only in the companies having prime contracts for major electronic equipments and systems. It must also exist in the little companies engaged in the design of some small bit or piece going into the equipment or system.

It Can Be Done

This factor is so essential to the attainment of reliable electronic equipment that I believe the military departments should discontinue awarding development contracts to companies whose managements do not appreciate the importance of good design to the national defense and do not insist on the establishment of the philosophy of excellence in design all the way down through their organizations.

• **If the various** technical design factors now known to be essential to reliable equipment are applied and if the management philosophies discussed above are adhered to by those in the military who are responsible for program direction, as well as by management in industry, electronic equipment can be built which will have several times the reliability of the average equipments currently going into service.

There are two important "ifs" in this statement. However, I am convinced that a marked improvement in the level of reliability will be attained generally within the next few years.

Unfortunately, this optimistic note does not mean that the electronic-equipment-reliability problem is reaching final solution. At the same time the military and industry are laying the foundation for substantial reliability improvements, the demands for still greater reliability are being created by the continually increasing complexity and performance requirements of new weapons.

The degree of reliability which would bring high praise from the operators of an aircraft-radio equipment today could very well be completely inadequate for some weapons now in the planning stage.

The designer of military electronic equipment and those that control his freedom to accomplish good, thorough design have largely been responsible for the poor level of reliability of the past. However, these same people are responsible to a large degree for the gratifying advancements now being made in reliability, and they will be largely responsible for meeting the challenging and extremely formidable problem of designing electronic devices of sufficient reliability to make possible the weapons of the future. ◈◈◈

Transistorized Navaid

Radio Corp. of America model MBRT-1 marker beacon receiver is believed to be first all-transistorized electronic navigational aid for aircraft. Using junction transistors and printed wiring, unit is housed in either a panel, bulkhead or ¼ ATR mounting. Panel adapter unit, shown in three-light version, is only 5 inches wide, weighs 15 ounces. Receiver may be remotely mounted.

Synchronous Modulation is Proposed As Alternate to Single-sideband

A new technique—synchronous communications—has been suggested as a preferable alternate to the use of single-sideband techniques recently hailed as the logical replacement for conventional amplitude modulation.

A proposal to reconsider advantages of improving AM through a suppressed carrier technique was offered by Dr. John P. Costa of the General Electric Co., at the second annual Symposium on Aeronautical Communications in Utica, N. Y.

Costa said increased demands on communications have caused engineers to consider new modulation techniques irrespective of additional system complexity. Of these, he said, "single-sideband has been singled out as the logical replacement for conventional AM and a great deal of public support has been given SSB as a consequence."

Companies such as Collins Radio and Radio Corp. of America are developing SSB equipment for Air Force evaluation and Aeronautical Radio, Inc. has an SSB project and draft of a characteristic for SSB airline equipment. International Air Transport Association is considering operational and compatibility factors of SSB.

AM may be capable of far better performance than that presently employed in conventional systems. Describing work on prototype equipment operating at 2-32 megacycles and in development for the Rome Air Development Center, Costa compared relative advantages of SSB and the synchronous AM.

Identical signal-to-noise ratios appear at the receivers of both systems, he said. In addition synchronous AM has a two-to-one advantage in average power if jamming is considered. System complexity and easier maintenance is obtained with the new technique which is actually simpler than conventional AM.

"If a complete conversion to single-sideband were made, those who believe that twice the number of usable channels would be available might be in for a rather rude awakening," Costa warned. Spectrum space saving has been heralded as a prime advantage of SSB, but Costa said SSB transmission poses serious allocation problems that in some cases cause the advantage to disappear.

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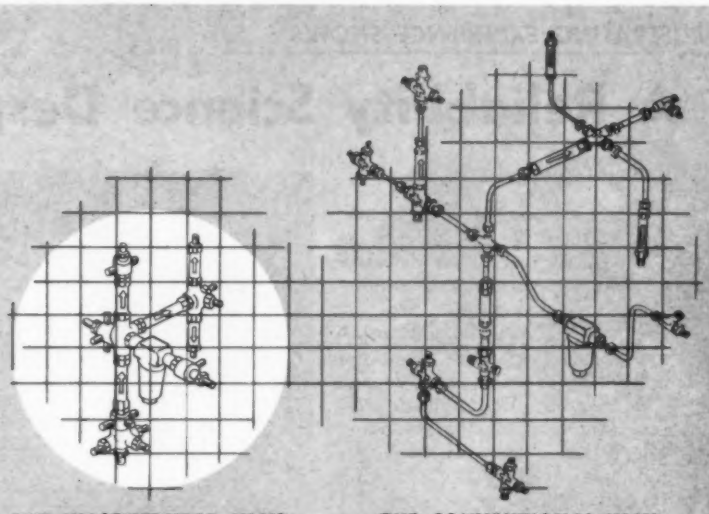

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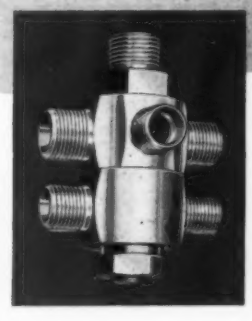

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ponents manufacturers and universities.

They believe proper management of all skills is the key to solution. This would include designers, quality controllers, industrial pyschologists and even the contract-writing lawyers.

AF Secretary Donald A. Quarles selected six points for attention in his review of the importance of the reliability improvement task in 1955. He said:

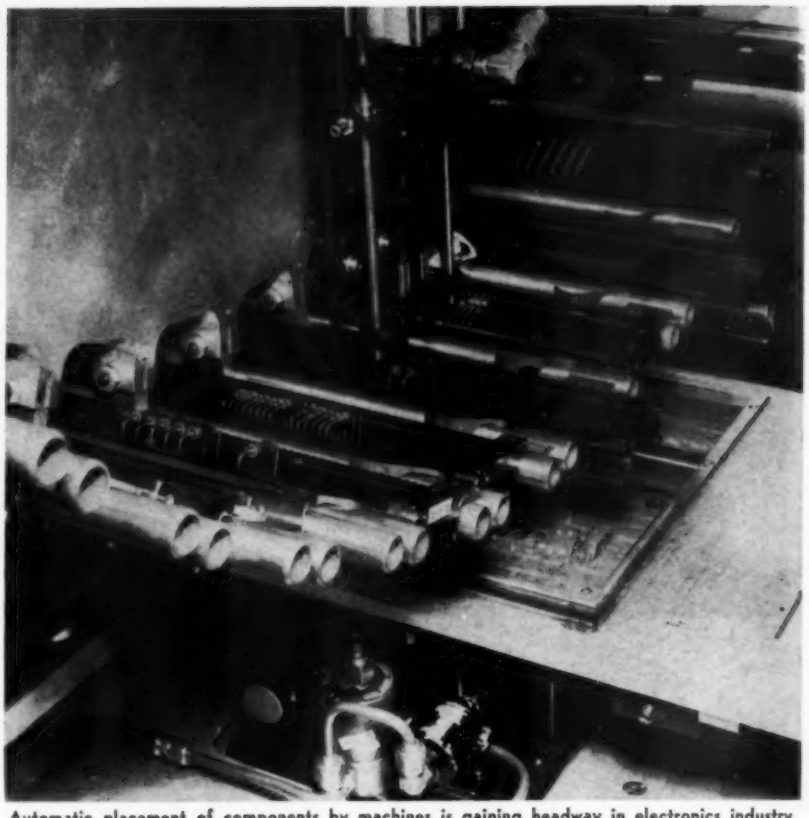
- "The military at pretty much all levels have come to appreciate this problem and are determined to correct it. As evidence I might cite the reliability consciousness of the three military departments and some two or three hundred research and development projects specifically directed toward this end."
- "There is abundant evidence that industry is ready to pitch in and do all it can, provided only it can receive proper directions."
- "A new branch of technology is springing up which might be called reliability engineering, that makes it possible to assign quantitative values to what had previously been a somewhat vague quality."
- "The Munitions Board has recognized the futility of trying to procure integrity and reliability, particularly in the development phase through present government competitive purchase practices and is actively seeking a better solution of the problem."
- "The guided missiles people, both in industry and in government, are becoming reliability conscious to the point of insisting on subjecting missile system designs to reliability engineering scrutiny. If this is done realistically it may delay the new era of pushbutton warfare, but if and when the era does arrive we will be a lot surer it has come to stay."
- "Competing equipments are coming to be evaluated not only in the number of tricks they will perform, but also in the reliability of service they can be expected to render."

A Young Science

History of Department of Defense attempts to find a sound approach to reliability started in 1950. An ad hoc group within the old R&D Board was set up to look into the problems.

At the end of two years the group turned out a report with 17 recommendations. One was a recommendation to form a permanent advisory body in DOD to advise on further pursuit of the matter.

In 1952 an advisory group on reliability of electronic equipment was established. Until 1955 it was active



Automatic placement of components by machines is gaining headway in electronics industry. GE's semi-automatic machine, shown inserting resistors in printed wiring board, was built for small volume military production to eliminate human error and speed up production. Resistor magazines sliding on tubes move into place over wiring board where resistors are picked up by placement head and inserted.

Quality control in manufacture of precision cageable gyros from 1,500 hand-assembled parts in Minneapolis Honeywell's Aeronautical Division plant is an important step toward reliable field performance. Hundreds of tests and never-ceasing battle with the "unseen" foreign particle requires special garb and round-the-clock vacuum-cleaning in areas like this one.

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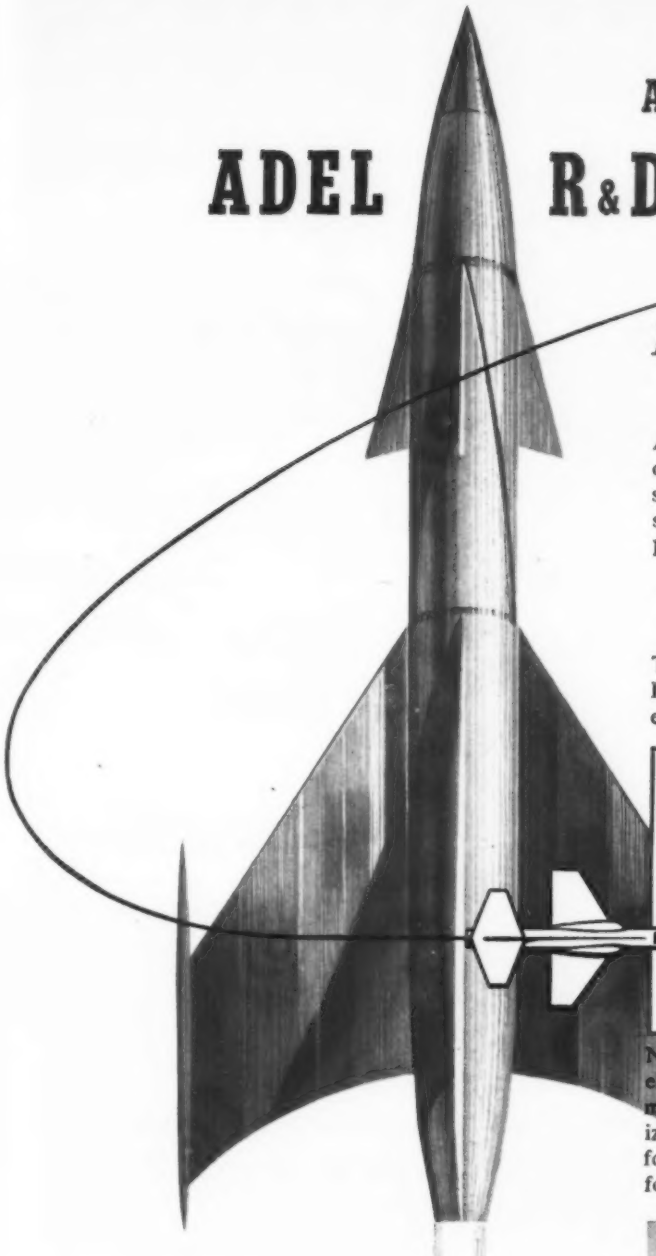

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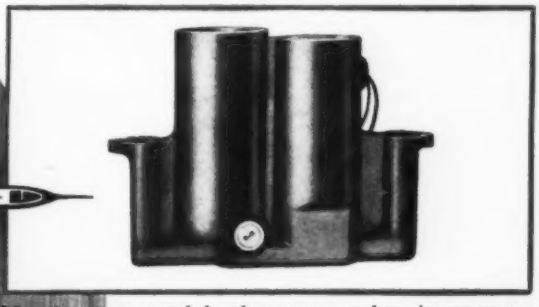

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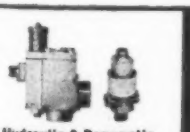
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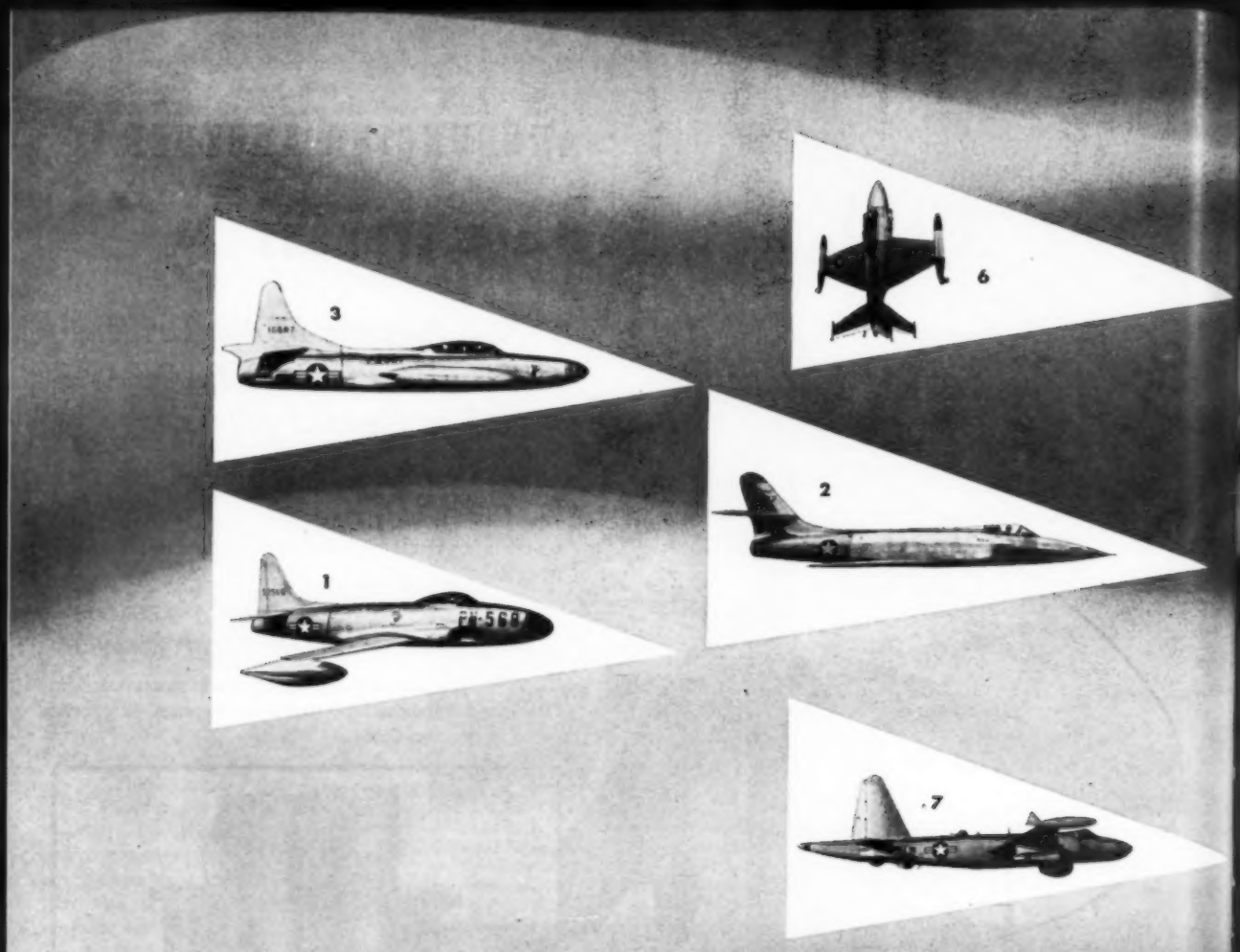

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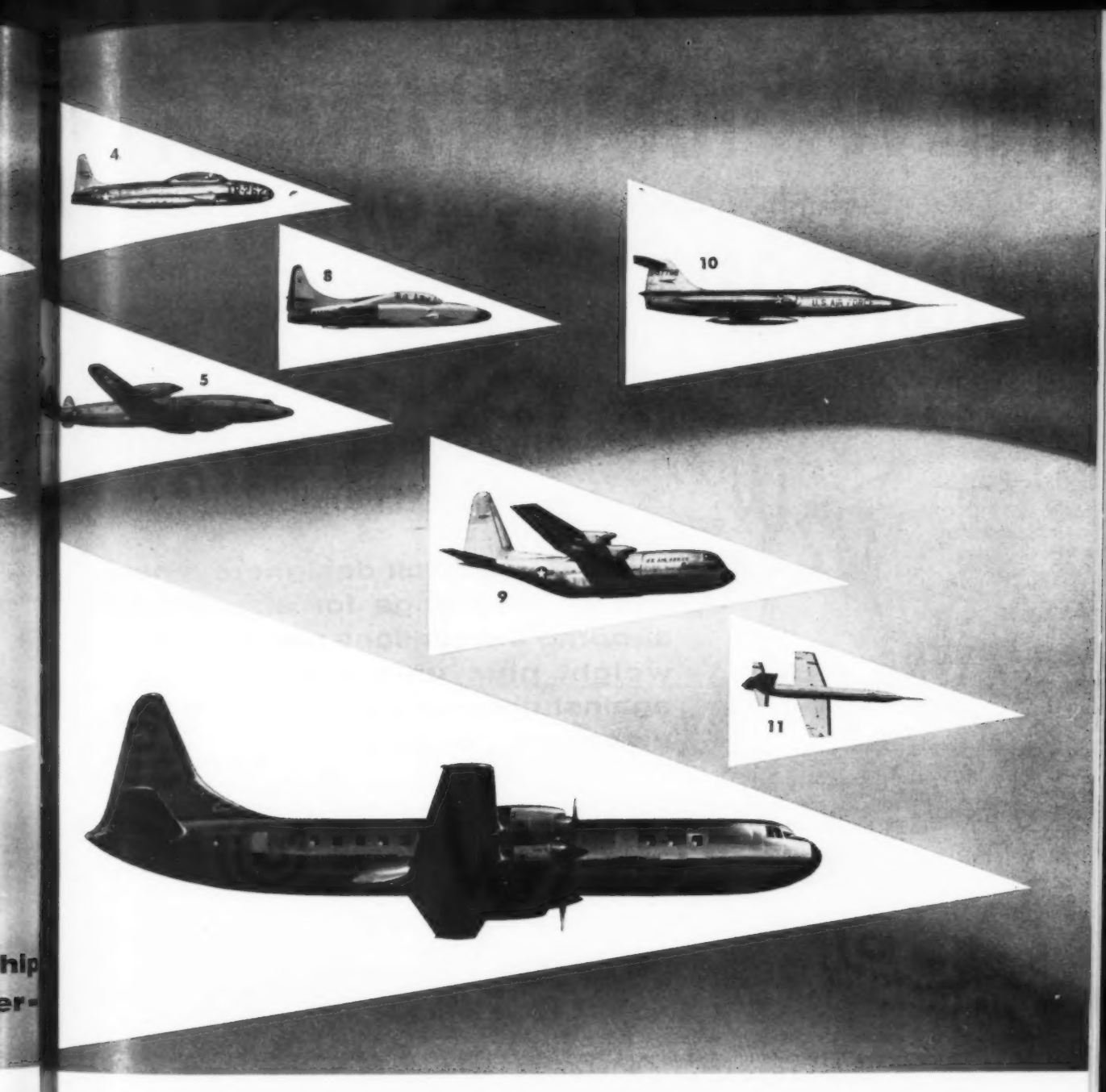

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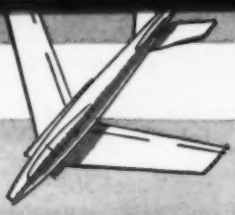
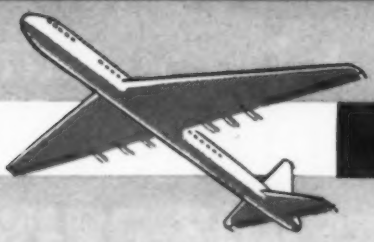
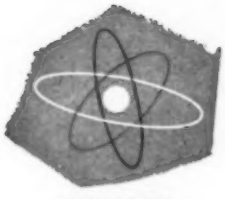




LEADER IN LANDING GEAR

BENDIX BUILDS BEST!



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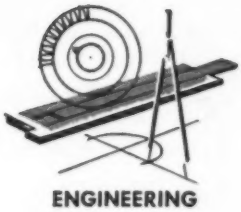
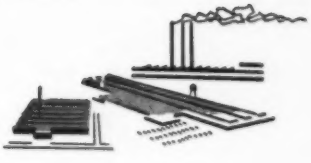


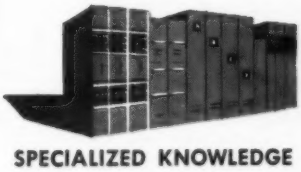
ENGINEERING



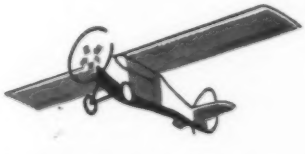
MANUFACTURING

SERVICE

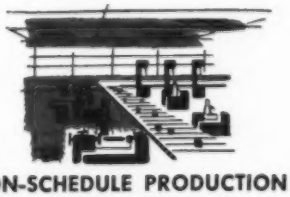
FINANCIAL STABILITY



SPECIALIZED KNOWLEDGE



PREVIOUS ACCOMPLISHMENTS



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The fact that Bendix Products Division of the Bendix Aviation Corporation has specialized for more than thirty years in two highly technical phases of aviation—fuel metering and landing gears—makes this organization unique in the industry.

During this unparalleled record of service in engineering and manufacturing of vital aircraft components, every resource and facility of Bendix Products has been constantly expanded to meet the challenges of new plane and engine design. Bendix Products has done far more than just keep pace with the industry. It is no exaggeration to state that in instance after instance in the fields of fuel metering, landing gears, wheels and brakes, Bendix sets the pace by developments making possible greater speeds, heavier loads and increased safety.

Thus, today, Bendix Products accumulative knowledge of research, engineering and manufacturing offers to air frame builders and engine manufacturers the best solution to better products, quicker deliveries and lower costs in fuel metering, landing gear, wheels, brakes, and components.

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mainly in publicizing the problem. It was a hard road to hoe. Neither the military nor the public much understood or really cared seriously about the problem.

Last year it was decided the advisory group had gone as far as possible with a generalized approach. What was needed was the solution of specific problems.

• **Originally** five permanent working groups were responsible for technical design, operations and procedures, supply and logistics, failure reporting and reliability publications. Their missions were vague. They were supposed to discover problems and recommend solutions.

Military department people attended meetings and heard recommendation. No record was kept of results. As a result of slow progress through these methods, it was decided to formalize the activity and implement the work by formalized studies and recommendations through working groups.

'AGREE' Expands Search for Reliability

An advisory group on electronics reliability is now searching for a formalized approach to reliability science. Its membership includes representatives from the Offices of the Assistant Secretaries of Defense for R&D, Applications Engineering, Supply and Logistics, and the Joint Chiefs of Staff and the three military departments.

Known as the Advisory Group on Reliability of Electronic Equipment (AGREE), it operates under the Office of the Assistant Secretary of Defense, Applications Engineering. Chairman of AGREE is J. M. Bridges, Director of Electronics, OASD.

• **Participating in the main group** besides military members are three regular members from industry and four industrial consultants, together with observers from the three military services.

Industrial members are Louis M. Clement, vice president, Crosley division, AVCO Mfg. Co., M. C. Batsel, Government and Industrial division, Radio Corp. of America, and F. J. Given, vice president, Sandia Corp.

Consultants are Dr. Cledo Brunetti, General Mills, Inc., J. A. Chambers, Phoenix Research Laboratories, Motorola, Inc., J. G. Reid, Jr., National Academy of Sciences, and Richard F. Rollman, Bell Telephone Laboratories.

Task Groups

To follow different facets of the reliability problem, AGREE organized nine task groups. These began operation in February 1956. Chairman of each group is from industry, and task group membership includes representatives from the three military services, as well as industry. Ratio of military to industry membership is about 2:1.

The task groups began their work last February. Optimistically it was expected their first reports would be available in six months. However, completion date was pushed back to the end of 1956. First reports have been completed from Task Groups 4 and 8.

It is the intention that reports from all the groups be integrated and revised so that compatibility between the concepts proposed is obtained. These are the tasks:

• Develop a "minimum acceptability figure" for reliability of various types of military electronic gear.

• Develop "basic requirements" for tests on development models to determine if task "1" is met.

• Develop "basic requirements" for tests on pilot-production and production models to determine whether task "1" is met.

• Study and propose methods of specifying design procedures to meet required reliability.

• Establish criteria and methods of specifying reliability of component parts.

• Determine compatibility of present procurement and contracting practices with reliability objectives.

• Study practices of packaging and means of improving them for increased reliability.

• Study effects of storage on reliability.

• Review methods and procedures being used to keep equipment working at a specified level of reliability. This would include maintenance, testing, and personnel training.

Military Department Activities

The Bureau of Ships operating through the Undersecretary of the Navy has had a full-time going organization working on reliability for a few years.

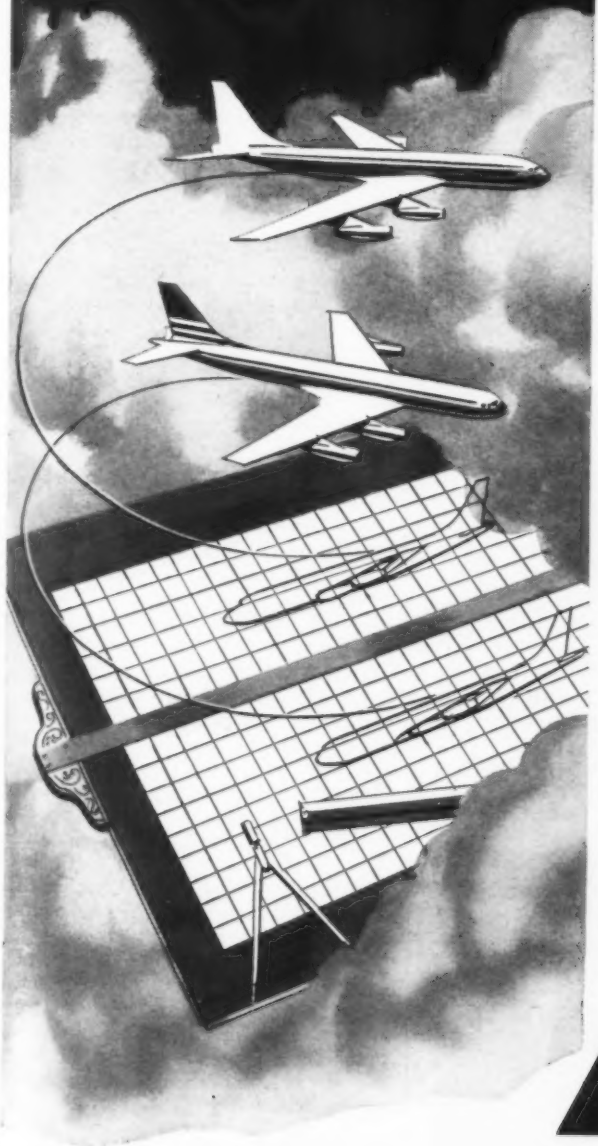
A study made by the Navy in 1950 showed that only 33 percent of electronic equipment in the Navy was working satisfactorily. In 1951 the Navy diverted a sizable portion of its engineering effort into "reliabilization" of electronic equipment.

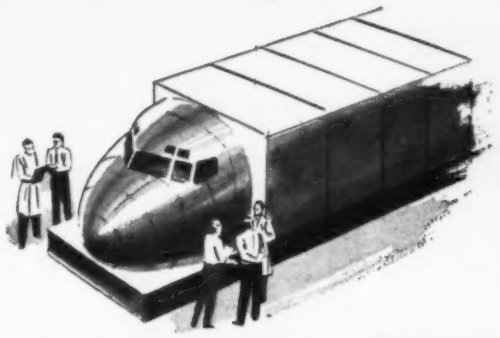
• **Based on** a problem assignment from the Bureau of Ships, the Naval Electronics Laboratory in San Diego, Calif. set out to develop methods and information for increasing simplicity, economy, and reliability of electronics

Circuit analyzers such as this one made by DIT-MCO for Minneapolis Honeywell help insure complete checkout of 110 relays in an automatic flight control system amplifier. One-minute test checks for continuity and shorts and reduces human error in what would be a many-hour test without automatic tester aid.

Flying Tomorrow's Jets

RIGHT OFF THE DRAWING BOARD





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The Simulator behaves exactly like the prototype aircraft – even uses an identical crew compartment. All controls and instruments function as they do in actual flight. Crews rehearse world air routes under varied weather and navigational conditions. A "trouble console" conditions the pilot's reflexes against all possible emergencies. Simulators built by Curtiss-Wright have resulted in savings of millions of dollars, thousands of manhours yearly for the world's leading airlines.

Curtiss-Wright has developed and produced more types of Simulators than all other manufacturers combined – with types now in production or service for aircraft powered by piston engines . . . piston engines plus jet engines . . . multi-jet engines . . . and turboprop engines. This proven experience is reflected in performance, dependability and fidelity of Simulators built by Curtiss-Wright – and by documented cost reductions and increased crew efficiencies in all types of military and commercial aircraft flight training programs.

ELECTRONICS DIVISION
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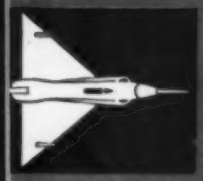

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Military Number MIL-/22	AMPHENOL Number	Nom. Imp. Ohms	Max. Oper. Volts R.M.S.
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87A	421-250	50	4000
115	421-641	50	4000
115A	421-699	50	4000
116	421-378	50	4000
117	421-377	50	5000
118	421-374	50	5000
119	421-358	50	5000
120	421-388	50	5000
126	421-443	50	2000
140	421-379	73	1700
141	421-382	50	1500
142	421-385	50	1500
143	421-388	50	2000
144	421-391	72	3000

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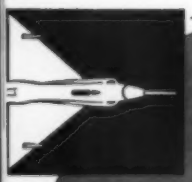

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Only AMPHENOL provides connectors to go with the Teflon cable it makes—not only a single-source advantage but also a guarantee of engineering responsibility. Latest addition to this RF connector line are Captivated Contact connectors in Series N and HN. These assemble with 87A, 115 and 115A Teflon cables, provide *added* reliability.

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equipment. It is called Project SER (Simplicity, Economy, Reliability).

In what is probably the first work of its kind, NEL has published the results of its work in a looseleaf handbook known as "The NEL Reliability Design Handbook."

The handbook is being continually developed and includes a vast amount of information affecting reliability, general and specific matter on equipment, design, parts information and application of parts data, design guide lines and procedures, failure history data, preferred circuits, and preferred assemblies.

• **Captain H. E. Bernstein,** USN, Commanding Officer and Director, U.S. Navy Electronics Laboratory, describing the efforts of NEL's program, said: "I would like to frankly admit we don't know everything. We are using what we have, and using anything we can beg, borrow, or steal to help out our program."

Together with the Bureau of Ships program there are the hundreds of military and industrial reliability projects related to specific contracts. Each tackles a specific facet of the problem related to components, equipment, or weapons systems. A vast amount of money is poured into this reliability work.

Witness to this is the amount of literature available on the subject. NEL has prepared the NEL Reliability Bibliography under an assignment from the Bureau of Ships and in accordance with the suggestion of AGREE. It contains abstracts of 400 publications on the subject of reliability.

• **The Air Force,** through the Air Research Development Command and Air Materiel Command, has of course responsibility for design, development, test and maintenance of "reliability" in electronics gear.

But in the Air Force as with the other services knowledge about reliability is inadequate. The system of design with military specification parts and construction is not working.

Obviously the present procedure of design acceptance, test, procurement, production, acceptance, maintenance and feed-back of information on performance is not doing the job fast enough or well enough for today's needs.

Reliability Research: A Science in Making

Formation of a reliability science or methodology is just beginning. The greatest effort is being directed to the field of least experience—electronics.

History of the expanding search for greater reliability in electronics can

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probably be said to have started with studies of ways to improve the reliability of the vacuum tube.

Research toward this end got off to a sound start in Aeronautical Radio Inc. ARINC is a corporation in which all the United States airlines are the principal stockholders.

• **Among ARINC's activities** is the Airlines Electronic Engineering Committee composed of airline technical personnel. Through AEEC, standards for electronic equipment and systems for the airlines are formulated. It is concerned also with operational, engineering and maintenance deficiencies and provides liaison for equipment manufacturers on technical problems related to airline airborne electronics programs.

Mounting dependence of the airlines on electronics at the end of World War II brought with it the conclusion that it would be impossible to operate unless improvement was brought about, especially in the vacuum tube.

ARINC invited the tube industry to a meeting in 1946 at which the airlines' dilemma was to be presented. It was proposed that ARINC act as the information feedback loop through which a tube improvement program could progress.

Indicative of the interest in reliability at that time is shown by the record. Only two companies were interested in participating. These were the General Electric Co. and Raytheon Manufacturing Co.

The aim was to develop 10 reliable tube types. The two companies divided the list and went to work, with ARINC developing the data and cooperating with engineers on both sides.

The tubes were developed. Then the Korean War broke out and the military services took the entire output of airlines approved tubes. Following the results with those tube types, the military services offered a unique contract to ARINC.

The original contract called for ARINC to investigate the nature, causes, contributing conditions and corrective measures to eliminate or reduce tube failures.

Scientific Attack

Dedicated to the elements of the scientific method, under the direction of C. Raymond Knight, the Military Contract Department of ARINC was formed, to carry out a contract let by the three military services and administered by the Navy.

Early in its program ARINC's Military Contract Department set five objectives for itself. These are:

• Determination and description of the status of military electron tube reliability as it existed before the advent of the improved tubes.

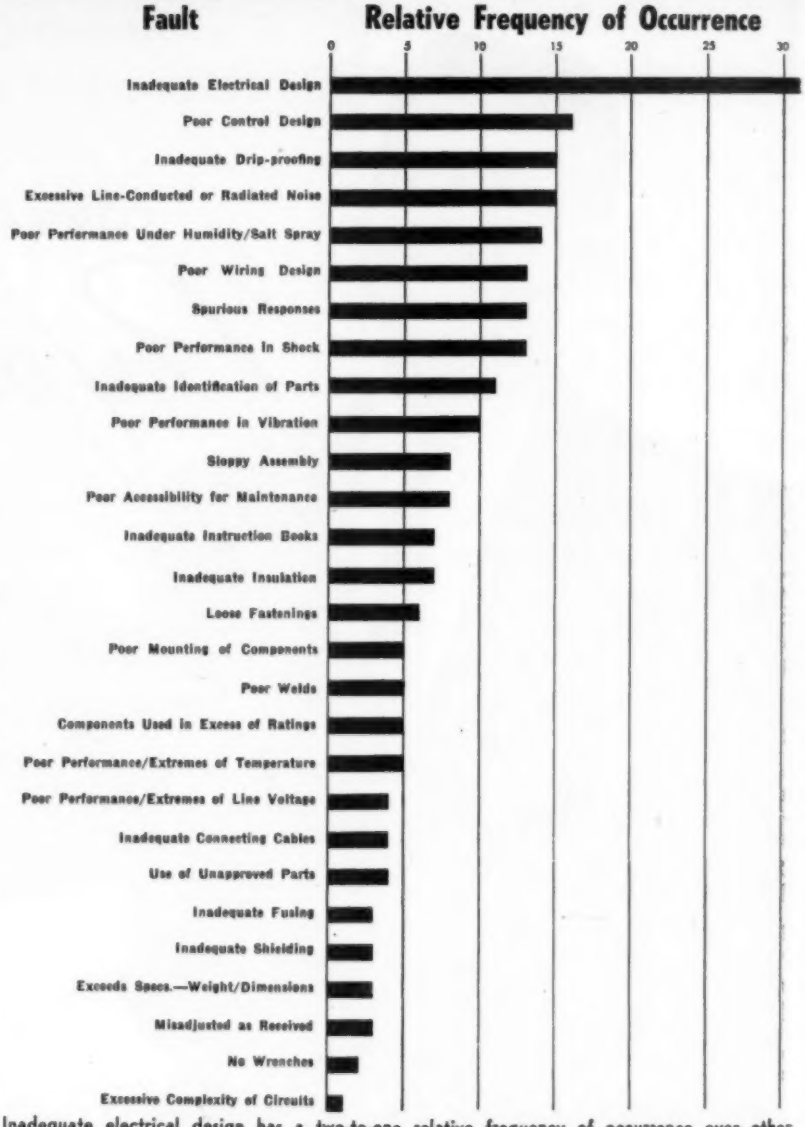
• Determination and description of the improvement effected as a result of the tube improvement programs of the various military services.

• Development of techniques for calculating equipment reliability while the equipment is still on the drawing board or at least in the pre-production stage.

• Development of laboratory tests which closely simulate environmental conditions in the field, and which can be used by tube and equipment manufacturers for quality control and design testing.

• Recommendation of tube design principles, equipment design principles, and maintenance practices that will contribute to greater equipment reliability.

Objective No. 1 is complete and objective No. 2 is continuing. Work has begun recently to move into the remaining objectives. Some idea of what the steps in the scientific method entail is indicated in MCD's first tube studies.

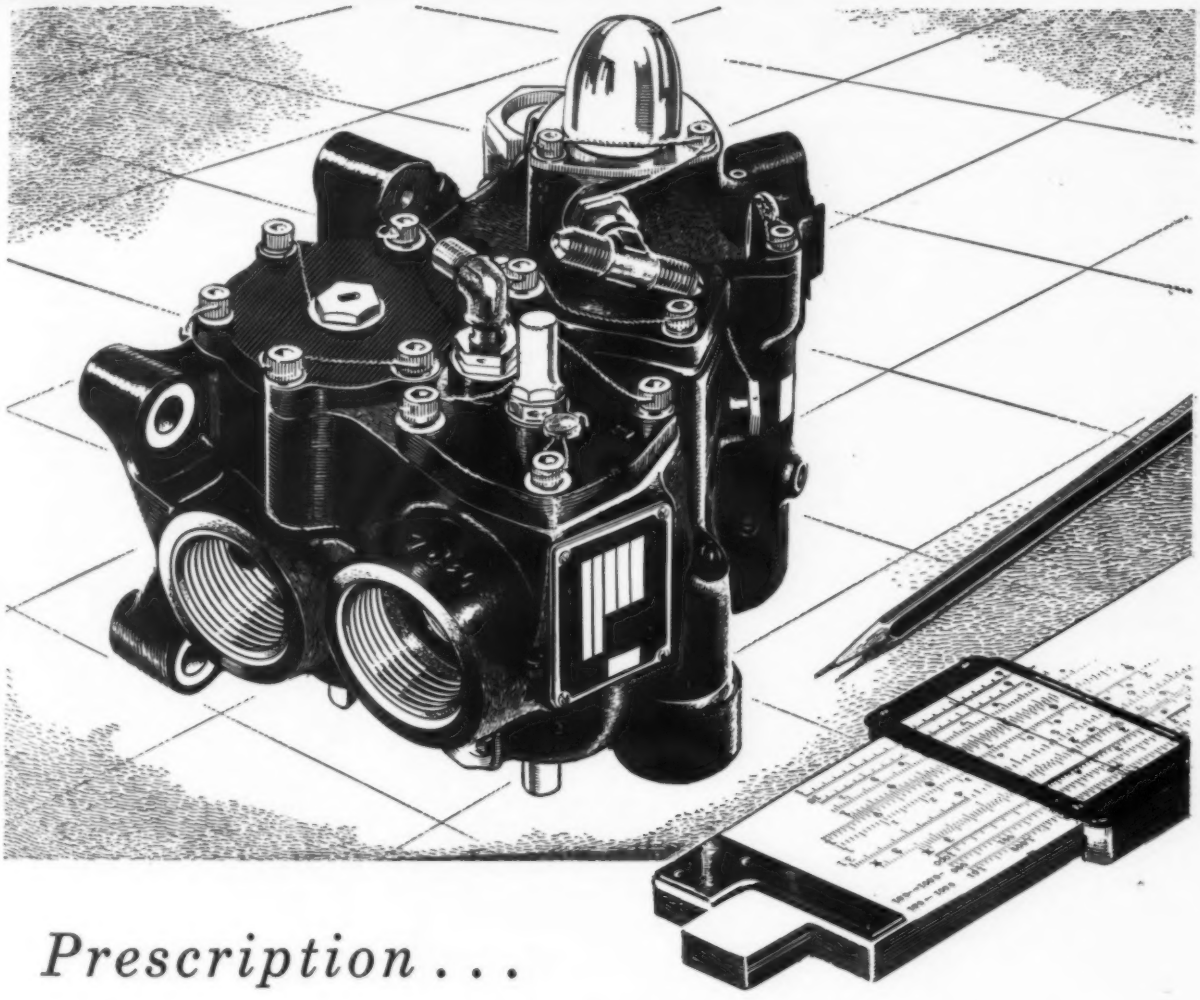


Inadequate electrical design has a two-to-one relative frequency of occurrence over other equipment faults in this record prepared by the Navy Electronics Laboratory from data gathered on prototype equipment. NEL blames faults on premature submission and inadequate contractor tests.

Definition: Knotty Problem

First step was to define reliability. Seemingly a simple problem, it was and still is a knotty problem. Widespread use of a "rubber" yardstick to measure reliability probably has been the greatest deterrent to ever achieving it.

Real progress in science depends upon measurement so that relationships may be expressed mathematically. Only



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in this way can other experimenters duplicate results and the efforts of widely separated groups be useful to all.

The use of statistical analysis and the mathematics needed to express it required adoption by ARINC of a definition that had meaning in mathematical use. The definition:

"The reliability of an electronic *product* is the *probability* that the product will give *satisfactory performance* for a given period of time when *used in the manner* and for the purpose intended."

From 1951 MCD grew from seven personnel to 107 in 1955. Eight field stations were established. Seven were within the U.S. and one in Germany. The flow of data mounted rapidly and failed tubes reached 4,000 a month in 1954, at which time 500,000 tube sockets were under surveillance.

In addition a guided missile tube study was inaugurated. And in 1954 investigation of large groups of tubes gave way to designed experimentation on small quantities.

• **Name of MCD** was changed to Reliability Research Department in 1955. From then on major effort was directed to a better understanding of relationships between component reliability and systems reliability, and the development of sound methods of reliability prediction.

RRD has followed the sequence of the scientific method by defining, investigating, generalizing, verifying, and is now at the stage of repeating and re-evaluating in tube research. Equipment studies are in the investigating stage.

The scientific road is a long one. Certain generalizations about tubes have been made such as:

• "Improved" tubes are really improved.

• Level and training of maintenance have an appreciable influence on apparent tube reliability.

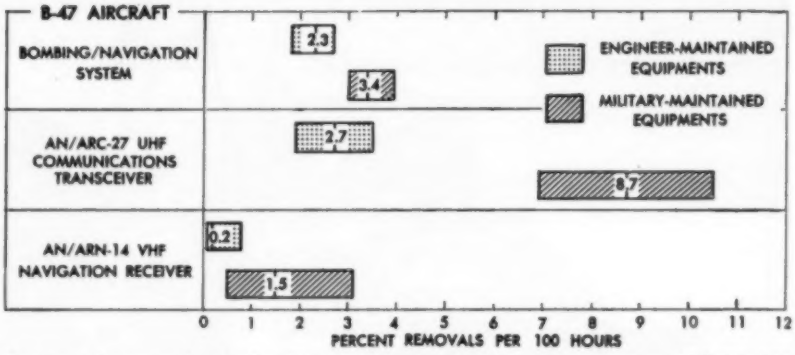
• Heater voltage applied to electron tubes in certain aircraft applications produces a serious detrimental effect on tube reliability.

• Operating temperatures on the electrodes and envelopes of tubes have a pronounced effect on their reliability.

The Human Problem

RRD considers the important subdivisions of the general reliability problem to be: tolerance, deterioration, the human problem and measurement.

Nearly ten years of experience in reliability leaves RRD with the view that reliability is the direct consequence of the interaction of stress and strength. The problems can be solved by improving strength, reducing stress or by a combination of the two.



Electron tube removal rates for three equipments at one air base. Based on ARINC'S RRD data, the effect of maintenance personnel training levels on apparent tube reliability is important. Removal rates are higher for military-maintained than engineer-maintained equipments. Needed are design considerations for maintainability by relatively unskilled personnel.

To RRD it seems unrealistic to study tubes alone without consideration of whole systems, environmental factors affecting operation, and the personnel who use and maintain them.

It believes generally that the less human beings know about a subject the more likely they are to view it in terms of black-and-white extremes. This tendency hampered early work on tube failure problems, and consisted of the belief that all tube failures were catastrophic.

The concept is just as wrong for systems. There is great difficulty in determining the exact line of demarcation between satisfactory and unsatisfactory system equipment performance. Seeking for a single fault sometimes hides the real problem that a group of black boxes were not adequately planned to work compatibly.

Interactions between humans and machines, RRD believes, is very important and more frequently neglected than interactions between hardware.

"People," RRD points out, "have to work with the black boxes and components, and these people cannot be expected to have the same degree of technical knowledge and familiarity with the equipment as the men who designed it."

• **Lawrence A. Hyland,** vice president, Hughes Aircraft Co. directed attention to some of the human angles in a talk before the Radio Electronics Television Manufacturers Association this year. Said Hyland:

"There is no mystery in electronics, but there is a good deal of sophistication, individuality and a subtlety of adjustment which, once mastered, results in expected performance.

"It behooves the military departments to accelerate their education and understanding of the capabilities and limitations of electronic operations so that they will have a first-hand feel for and judgment of the performance."

One study of ARINC's RRD was done to determine the effects of different levels of maintenance skill on *apparent* tube reliability. The experiment was carried out at Air Force bases using B-36 and B-47 aircraft. a Navy air installation, a shipboard installation, tanks in an armored division of the Army and an infantry division.

Combined data for three types of airborne systems at two different Air Force bases showed a tube removal rate per 100 system-operating hours maintained by military personnel to be about double that for equipments maintained by engineers. Data from Army equipments showed about the same result.

Under the present draft law men are being asked to become both soldiers and electronics experts, and still have time to do maintenance—all in a few years.

RRD data shows the maintenance man learning curve data from one Air Force base leveled off after seven months of experience with a relatively simple equipment. If the learning takes that long on a simple equipment, then on a complex one, RRD concludes, the personnel will never pass the initial learning stage within average turnover time in the military services.

• **Better human engineering** in military equipment is thus shown to be mandatory. In the ultimate, malfunctions blamed on operator and maintenance errors are due to poor human engineering in equipments.

The time will come when reliability will be calculated while equipment is still on the drawing board. A new Air Force Reliability Assurance Program has been started. It combines the theoretical and experimental approaches to the problem.

The program concerns the evolution of techniques for predicting field

reliability of systems at three developmental stages before field use. These are: the drawing board stage; laboratory bench-test stage; engineering flight-test evaluation; experimental vehicles for verification tests of the techniques developed.

The task at hand has impressive dimensions. A standardized terminology and definite units of measurement will be required. The exact nature of the problems must be clearly defined.

Organized, systematic and well-planned scientific methods of analysis and study of the individual problems must be the route to any real improvements in reliability. Perhaps the task forces of AGREE will be the agency through which this is finally done.

• **Assignment of responsibilities** in each of the problem phases will undoubtedly be met with antagonism and confusion. But the writer believes the

C. R. KNIGHT
Director of ARINC's Reliability Research Department

day will come when reliability will be written into a contract just as dimensions are.

This prospect could denote the need for a whole reorientation of procurement policy away from a purely cost-competitive approach. Reliability will cost something for the manufacturer, and know-how will have new dimensions.

It will be the manufacturer's responsibility to have and use people who know the reliability science and it will take these people time to build it into equipment.

New standards of coordinated application of the reliability science must be established and met. Education at the university level will no longer be able to leave part of the learning process to industry where learning by feedback of failure information gives a man "experience."

Traditional concepts of chief engineers and managers as super-experienced beings who know all the pitfalls may be forced to give way to the concept that omniscience does not exist in human beings—that reliability can only be achieved by knowing the methodology of applying that science. ◈◈◈

Fireman makes ready for an acid fueling standby at Holloman Air Force Base, N. M. Note clothing which is acidproof. William B. Oney, Base fire chief, says, "We must have a breathing apparatus which is dependable, and Scott Air-Pak sure fills the bill."
The American City Magazine

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Can Helicopters Achieve Desired Reliability?

Army is waging a major campaign to improve reliability of its most useful and cantankerous aerial beast—the helicopter.

Its objective: 1,000 hours between major overhauls for all helicopter components.

Rotary wing aircraft have come a long way since the grim days of Korea, when some Army units reported as much as 300 hours of maintenance for each hour of flying.

Today, particularly in the smaller helicopters, the Army is getting one hour of operation for about seven or eight maintenance man-hours. Nevertheless, this is about twice as much support as required by a comparable fixed-wing aircraft, the Cessna L-19, and Army feels it still has a long way to go.

• **Here's how Maj. Gen. Hamilton Howze,** director of the Army Aviation Division, expressed it in a blunt speech to the American Helicopter Society last spring:

The helicopter, as it now stands, is "unacceptably" expensive to the Army. It is "unacceptably complex," and the life of its components is "unacceptably short." The maintenance problem, despite undeniable progress, "remains simply flabbergasting."

"I hope you understand that a low availability rate for helicopters does not by any means react towards increasing the requirement for the number of them. Its effect is quite the opposite: low availability and high initial and continuing expense make the article too rich in terms of cost per ton mile for the military to stand, and decreases the quantities of our purchase."

Conflicting Views

Some students of the helicopter reliability problem are inclined to take the view that the helicopter, by its nature, will always be an unreliable device regardless of the gadgetry and gimmickry designed to solve its problems.

Comments one Doubting Thomas: "You've got a rotor hub which has to support the weight of the machine and transmit power to the blades. At the same time, it must be sufficiently articulate to permit changes in blade pitch and attitude. Add to that a complicated transmission, long and complex shafting, a powerplant that must operate at full power for long periods, and unholy vibration, and you wind up with a costly, short-life machine."

But this gloomy view isn't shared by the Army Transportation Corps, which is responsible for a major portion of Army's present fleet of 1,400 helicopters. With another 900 cargo helicopters scheduled to be added to Army's inventory by 1960, the Transportation Corps has a big stake in bettering helicopter reliability.

"If we just wade manfully into the helicopter problem," declares one official of the Transportation Corps, "we can get everything to run at least as long as the engine." This ranges up to 600 hours on the Bell H-13 series. (See chart)

• **Ultimately, Army** is shooting for a life of 1,000 between major overhauls. This design objective is spelled out in a number of its contracts for new helicopter components and should serve as a major force in bringing the reliability of helicopters up to respectable levels.

But the Transportation Corps is also pushing distinct reliability improvement programs in the three major helicopter trouble zones: engines, transmissions and rotor hub/blade assemblies. These range from operational procedures designed to alleviate the strain on present helicopter components to long-range design and development contracts aimed at the improvement of specific components.

Improvements Anticipated

As in all aircraft, continuous improvements may be made during the active production life of a helicopter through a flow of trouble reports from user to manufacturer. As difficulties crop up in various components, engineering remedies may be cranked into the production line and retrofit kits may be produced for modification of existing models.

Another procedure is the use of the "red line" to restrict operation of helicopters to power and speed regimes assuring the longest possible life to existing components. The 260-hp Lycoming engine in the Bell H-13H is accordingly derated to 200-hp, while the 800-hp Wright R1300 in the Sikorsky H-19 is derated to 700 hp. This technique will also be used with gas turbine engines. The 825-hp Lycoming T53 will be derated to 700 hp in the Bell XH-40 utility helicopter.

• **For the most part,** however, operational restrictions, red lines and the like are merely attempts to live with an unsolved problem, and the price may run high in terms of performance. The same applies to engineering fixes, which usually nibble at the edges of the basic problem rather than plunge to the source.

Recognizing this, the Transportation Corps is conducting a strenuous testing program for all new helicopter components. It believes that a new transmission deserves the same testing cycle as a new engine, and that it is unrealistic to run an engine 4,000 to 6,000 hours before acceptance, while only demanding 300 to 1,000 hours from the transmission with which it will be mated.

Intimately related to this is an effort to ruggedize helicopter powerplants in order to get longer life. This is particularly important in the case of gas turbine engines, which will have to ingest sand and dust in large quantities in the Army environment. Efforts are currently under way to improve the Allison T56 and Lycoming T53 in this respect, and similar projects are planned for the Lycoming T55 and the General Electric T58.

• **The Transportation** Research and Development Command (TRADCOM) at Fort Eustis, Va., is conducting a number of studies aimed at spotting and eradicating reliability headaches in helicopters. One such project is a study of the causes of low service life or rotor blades. Another is a detailed report on all sources of helicopter reliability troubles during the past 10 years, to be published and distributed to manufacturers shortly. It is hoped that the study will help prevent the repetition of old errors.

The Army has also enlisted other

Life Span of Army Copter Components

According to current technical orders, the life span of major components of the most widely used Army helicopters is as follows:

Model	Engine	Transmission	Main Rotor Blades
H-13	600 hours	600 hours	1,000 hours
H-19	500 hours	150-250 hours	850 hours
H-21	600 hours	150-250 hours	250-450 hours
H-23	600 hours	400 hours	600 hours
H-34	600 hours	100-250 hours	500 hours

Catapult Officer gives the signal, and the Vought F8U-1 *Crusader* is hurtled along the deck by the Forrestal's steam catapult...

...airborne in a matter of seconds, the *Crusader* streaks skyward at a speed never before attained by a Navy jet fighter...

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The trials, held off the Atlantic Coast, marked the first time that an aircraft capable of level flight speeds in excess of 1,000 miles an hour had ever operated from a carrier deck.

Designed and built by Chance Vought, the *Crusader* met all of the Navy's stringent shipboard operating requirements like a champion. This blazing new air superiority fighter soon will be assigned to active duty with the Fleet, adding 1,000 miles-an-hour-plus performance to the growing strength of America's Defense Team.

Scientists and Engineers: There is a challenging place for you on Vought's creative team now. Write: J. W. Larson, Assistant Chief Engineer, P. O. Box 5907, Dallas, Texas.

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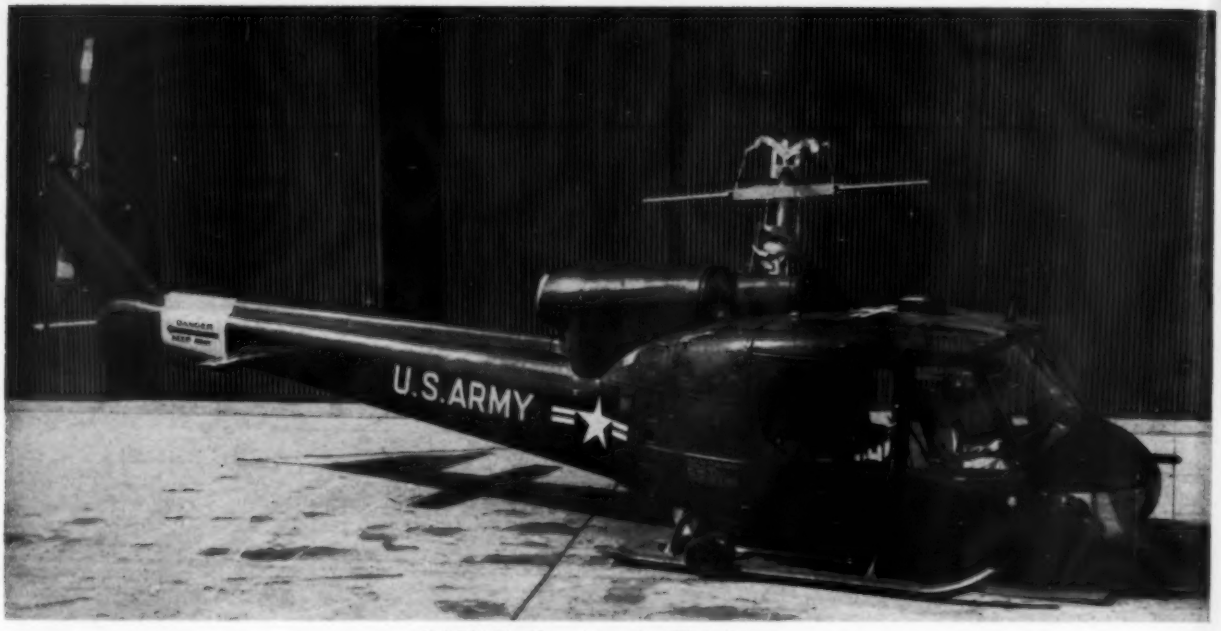


Bell XH-40 will use Lycoming T53 turboprop.

government agencies in its reliability campaign. The National Advisory Committee for Aeronautics, for example, has been conducting a long-term study of the causes and cures of helicopter vibration.

And the Civil Aeronautics Administration has been investigating the possibilities of crash-resistant fuel tanks and improved methods of fire detection and prevention.

New Components in Works

Perhaps the most ambitious of Transportation Corps' reliability efforts are its series of design and development contracts for improved helicopter components, many of them representing radical departures from present mechanisms.

• **Framm Air Filter Co.,** Providence, R. I., has a contract to develop an air filtration system for reciprocating engines which will minimize dust erosion.

In the transmission area, Bergen Engineering Co., a New Jersey firm, is developing a simplified eccentric sun-planet transmission which will require only 25% of the parts of present transmissions.

Along with Flettner Aircraft Corp., Kew Gardens, N. Y., it is also working on improved planetary transmissions like those conventionally used in helicopters.

A very considerable effort is also going into rotor hubs and blades. Piasecki Aircraft Corp., Philadelphia, has a contract to develop a simplified hub requiring fewer parts. Bell Aircraft Corp. is working on a hub for the XH-40 which will have only one-half to two-thirds the number of parts used in present hubs. Kellett Aircraft Corp., Camden, N. J., and Vertol Aircraft Corp., Morton, Pa., are also working on improved hubs.

A contract for the development of plastic rotor blades has been awarded to Vertol. Other blade improvement efforts are being conducted by Parsons Corp., Traverse City, Mich., and Prewitt Aircraft Co., Clifton Heights, Pa.

Altogether, these efforts may produce a far more reliable helicopter than is presently available.

At any rate, they should go far to prove—or disprove—this contention by one staunch Army supporter of the whirly birds:

"There's nothing inherently unreliable about the helicopter. The military simply rushed into the field long before there was adequate supporting research, development and testing. The price, unfortunately, has been the lack of reliability we encounter in today's helicopters. But it can be cured." ◆◆◆

X-2 Set New Record Before Crash

The Bell X-2's last flight was noteworthy in more ways than one. Air Force Secretary Donald A. Quarles announced that just prior to the accident Capt. M. G. Apt had flown faster than any man before in history. This would put the small steel research craft's speed at close to if not over 2,000 miles per hour. The X-2 had already flown 1,900 mph on an earlier flight.

The other notable aspect of the unfortunate event was a striking demonstration of the strength of all-steel construction. Observers who have seen the wreckage report that if it were not for the fact that it is used for research purposes, and thus is subject to extreme and often unpredictable stress, it could probably be rebuilt to fly again.

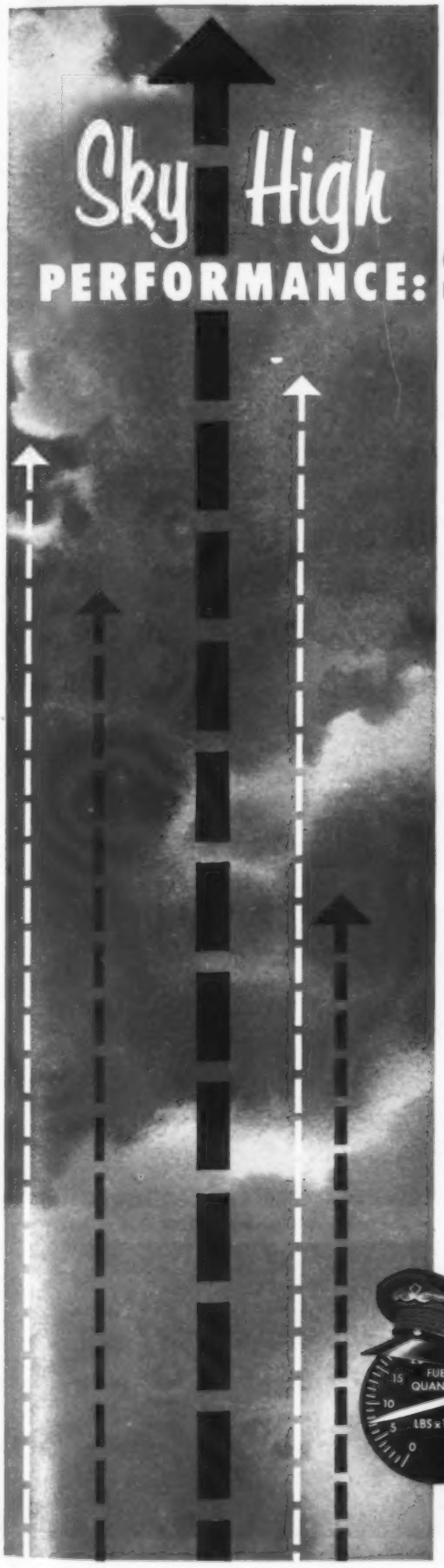
Piloted by Capt. Apt, on a first-time familiarization flight, the X-2 was released according to schedule at 30,000 feet, its rocket engines functioning perfectly. In due course it climbed at full throttle to 70,000 feet, and upon exhaustion of its fuel supply began a normal glide return to base.

• **It was in** the early stage of the glide that the radio cut out and the nose capsule containing the pilot separated from the rest of the aircraft and fell to the ground, its speed just slightly retarded by the drogue chute.

The rest of the X-2, its weight and balance thrown off by loss of its nose, went into a flat spin and hit in that attitude. Visual damage was relatively small. It did not scatter over the desert, nor did it dig itself a hole.

Engineers, however, fear internal damage must have been too great to warrant trying to restore it to flight test status.

Defense Secretary Wilson's office says that an additional formal statement will be issued regarding the cause of the crash when full details are known.



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Hotter and Hotter and More Expensive

By SEABROOK HULL

"Design a vehicle that can pass through the edge of the sun and come out flying . . .

". . . and now fix it so I can make the trip and come out alive."

It's impossible. But this is the goal that aircraft and missile designers are driving at today. Its importance was underlined earlier this month by the Society of Automotive Engineers' National Aeronautical Meeting at Los Angeles where the implications of high-speed, high-temperature flight were laid out in considerable detail.

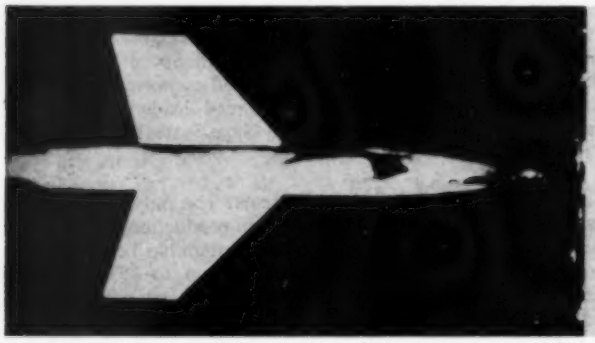
With operational aircraft already encountering 400°-to-500° environmental air temperatures and ICBMs that will generate 47,000°F shock waves already at the component test stage, the so-called thermal barrier is no longer a theoretical eventuality. It's a tough design problem that's here now.

Old Rules Out

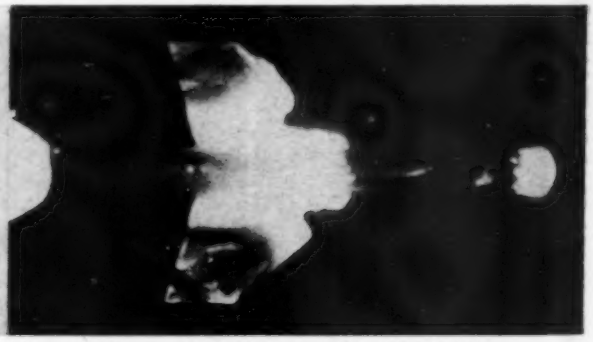
• **Not only** is it taxing the knowledge of materials researchers and aircraft structural engineers, it's forcing a fast evolution in a large number of proven, comfortable design, development and manufacturing techniques. Old rules are out; new ones, elusive. And at every turn the production department finds its equipment getting more complicated and expensive—just like the new materials it has to learn to "get along with."

To present this special report on the impact and potentials of ultra-high speed, high-temperature flight, AMERICAN AVIATION has talked with top researchers and engineers among leading materials suppliers and airframe and missile makers, and found that:

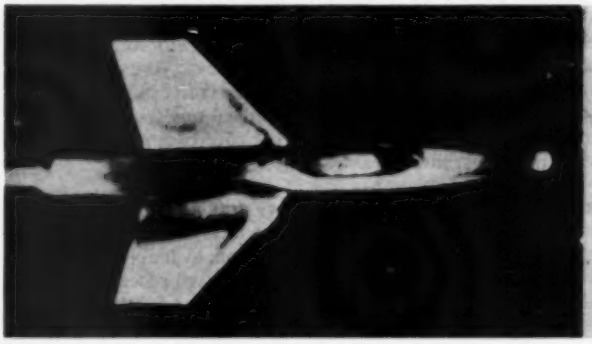
• Aircraft are being built to fly at 600° F temperatures; materials are known to take them to Mach 4.5 speeds and skin temperatures of some 1,600° F and short-lived missiles much faster and hotter still. But their workability still limits supply and usability. Materials suppliers—of steel, titanium, nickel-cobalt, molybdenum, cermets, ceramics



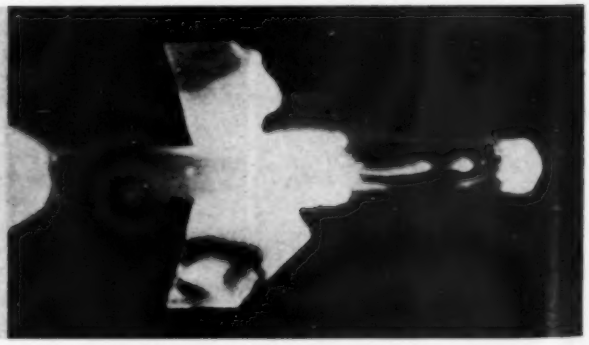
(1) O-seconds: Test model awaits hot blast of hypersonic flight.



(4) . . . at 4.0 seconds. Stainless steel flows like oil. Life . . .

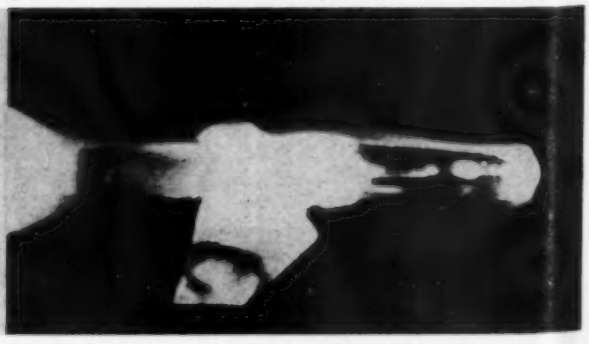


(2) . . . in 0.9 seconds nose and wing leading edges glow red hot . . .

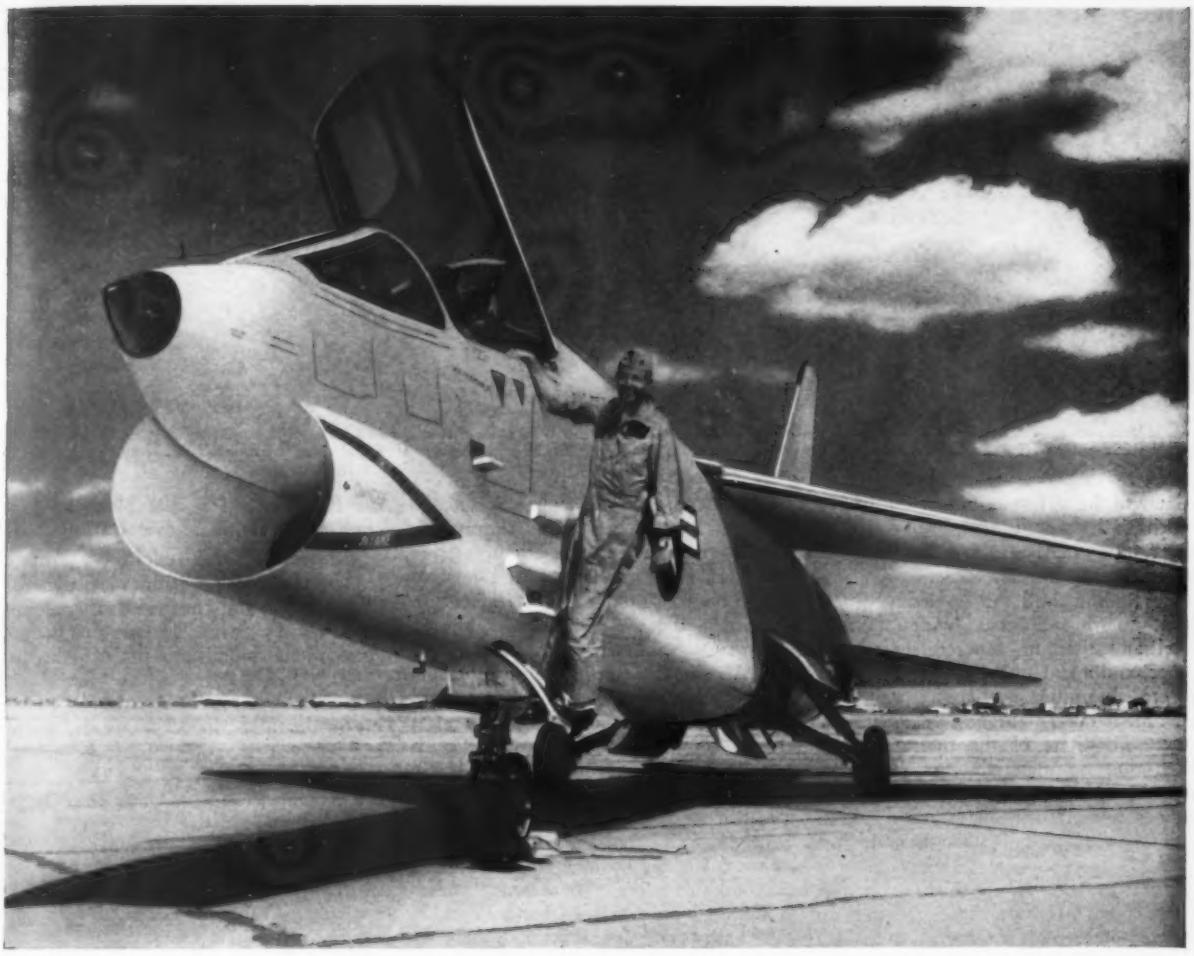


(5) . . . is hot and short at 4,500 mph, 50,000 ft. . . . 5.3 seconds.

(3) 2.5 seconds now . . . nose is blunt and fluid. Wings are melting . . .



(6) The end comes in 6.7 seconds. Problem: Put a pilot in it.



Commander R. W. "Duke" Windsor poses with the record-breaking F8U-1 "Crusader" immediately after his 32-minute jaunt. Plane flew more than 400 miles—all but eighty of them at supersonic speed.

Purolator Micronic® filters help set 1015.428 mph speed mark

On August 21, this Navy Chance Vought F8U-1 "Crusader" set a new national speed record of 1015.428 miles an hour and won the famous Thompson Trophy. The plane, a standard production model, made two passes over the 15.1 kilometer course—both of them at speeds nearly 200 miles faster than the previous Thompson record.

This record flight put every component in the F8U-1 to its severest test. For, at 1000 mph, every component must function perfectly—whether it's the powerful J-57-P4 engine, the instrumentation, or the vital fuel, lubrication and hydraulic lines.

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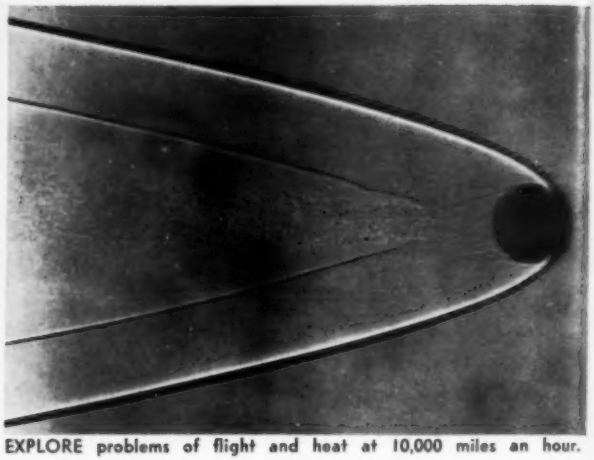

EXPLORE problems of flight and heat at 10,000 miles an hour.

—new to the airframe industry still have much to learn and spend in order to meet this market's requirements of volume, size and tolerance.

• Rolling mills can be designed and built to roll 120-inch wide stainless steel and titanium tapered sheet; also other equipment to bring new materials up to aluminum availability standards . . . all it takes is money.

• The state of the thermal art is such that no materials—not even diamonds, platinum, plastics, graphite, ductile ceramics—have altogether been ruled out as possibly "the best answer yet."

• Every new design idea, no matter how apparently fantastic, is assured an honest, interested reading.

• As aircraft operating conditions become more severe, design is to increasingly shorter life and more specific missions; as performance goes up, operational life and flexibility go down.

• Stainless steel aircraft, and to some extent titanium alloy components are still put together more by trial-and-error prototype methods than by relatively easy mass-production techniques such as those developed through the years for aluminum.

• As between designers and materials suppliers there still exists a considerable area of ignorance, each of the other's requirements and capabilities.

• The aircraft industry itself is doing more research to develop new materials to meet its needs than are materials suppliers.

• What is preposterous today will tomorrow be convention, such as wings and nose cones designed to melt, burn or sublime in flight and other one-shot, throw-away components. It means aircraft operating under missile conditions but with the ability to still return to base to fly again.

The cause for all this fuss is that when you mix plain ordinary air and very high speeds, the reaction is exothermic. At altitudes up to 350,000 feet, the heat generated is simply the kinetic energy of the volume (or weight) of air it brings to rest relative to the body in motion. The temperature to which the air is raised is known as the stagnant air temperature.

A simple rule-of-thumb formula for figuring how hot the air around your aircraft will get at what speed is $T_{st} = T_{am}(1 + M^2/5)$, where T_{am} is the ambient temperature of the still air and M is the Mach Number. Temperatures are absolute, i.e., Fahrenheit plus 460°. It's good for speeds up to Mach 3 and from 35,000 to 100,000 feet. Beyond these limits its accuracy diminishes but it gives results that are still "in the ball park" for some extension of both speed and altitude.

• **Somewhere above 300,000-350,000 feet,** aerodynamic heating ceases to be a real problem at any speed. For air is no longer a viscous, fluid mass, but rather a widely-scattered, free and independent system of largely unrelated, highly excited particles. These strike the vehicle only "occasionally," and while individually they've got the same energy as their more gregarious cousins below, the cumulative effect because of their fewer numbers is on a very low order.

The 'Thermal Thicket'

Today's operational aircraft are just beginning to edge cautiously into the "thermal thicket." The North American F-100C, for example, has no problems at Mach 1.3. At 40,000 feet where the outside air temperature is about —65° F, the Super Sabre's skin won't get over 75° F, no matter how long it keeps it up.

The Convair F-106 at Mach 1.5 would go to 140° F; the McDonnell F-101 at Mach 1.6, to 144° F; the Lockheed F-104A at Mach 2.0, to 252° F; the Martin XB-68 at Mach 2.5, to 417° F; the Bell X-2 at Mach 3.0, to 632° F. And if, as has been reported, the Republic F-103 is a Mach 3.0 aircraft, it too is in the over 600° F class.

• **So far,** this edging-in process has been relatively painless. For aerodynamic heating purposes, there was no cause to vary much from more or less conventional aluminum practices in the F-100, F-101 or F-106. Titanium and/or stainless steel does begin showing up in these aircraft, however, where engine heat is added to aerodynamic heat.

F-104 Still Aluminium

The F-106, for example, has stainless steel skin around the tail pipe and as the leading edge of the engine air intake, though this latter is probably more to protect aerodynamic cleanness from mechanical damage than it is to cope with any heating problem.

Even the F-104A's wings are still of aluminum. At over 200° F, aluminum does suffer some loss of structural integrity over long load periods, but the use of thick machined sections compensates enough for the extremely thin wings, high wing loading and a margin of safety all to be accounted for.

Actually stainless steel began showing up in military airframes much earlier—ribs, etc., around the engine in the F-86, for example—but this was solely to take care of engine heat.

The X-2, however, was operating in stagnant air temperatures some 250° F over the maximum safe aluminum temperature and was made of stainless steel and K-monel. The Martin XB-68 will be constructed largely of stainless steel and titanium, as, probably, is the F-103. The Convair B-58 contains considerable stainless steel honeycomb.

• **This is the nature** of the problem in its beginning. But this is an alpha-omega attack. Development of manned aircraft with temperature ac-

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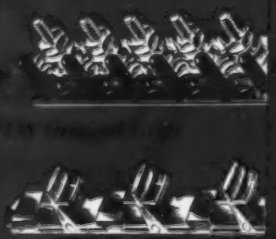

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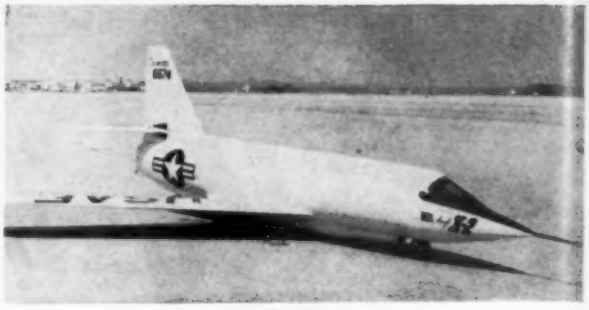
Lockheed XF-104: The last of aluminum wings . . .



Bell X-2: The first of steel.

countability is gradual and by increments. But the Inter-Continental Ballistics Missile program is simultaneously demanding answers to the ultimate, the omega of high temperature flight . . . before anyone's really aware of what's best down around the alpha stages.

'Near-escape Vehicles'

ICBMs are thought of as "near-escape" vehicles. They will plunge upward to a point where the atmosphere is no longer gas. Getting and briefly coasting there takes a lot of oomph, but few temperature problems are encountered.

But falling towards its target, it will accelerate to Mach 20 and will plummet unchecked into rapidly densifying air. Temperature in the shock wave that hugs the downward end of the tumbling ICBM warhead will reach the staggering level of 47,000° F. At this energy level, the shock wave will cause the air molecules to dissociate into atomic and ionic (charged) oxygen and nitrogen.

This reaction is endothermic, and as a result, the air just behind the shock wave will be lowered to a relatively "cool" 9,500° F. This is the temperature of the sun's surface, and there is no known material that will not vaporize under such conditions.

• **Dissociation is a phenomenon** that begins to come into play at temperatures around 3,000° F, but at that level the cooling effect is insignificant. At about 6,500° F, however, it begins to have a substantial cooling effect. This is useful in missile design today; in aircraft, tomorrow. Eventually, the dissociated molecules reform and dump the heat back into the air. But with vehicles traveling at ultra high speeds, this would normally occur behind the vehicle.

At present, the ICBM is the ultimate in "thermal barrier" problems. Achieving it as a usable operating weapons system is proving a lot more complex than the simple original act of dreaming it up.

Missiles are now under development that call for solving aerodynamic heat problems at every level between the relatively subdued Mach 3.0 aircraft and the ICBM.

The action of heat on vehicle structures brings into sharp focus two additional dimensions for the designer to worry about—time and temperature. In the case of present-day aircraft and tomorrow's designs, temperature is relatively low and time—either sustained flight at velocity or total aircraft life—can thus be relatively long. The saving grace of missiles, which are very high speed, is that time of flight at velocity and total life are short. And it only has to fly once.

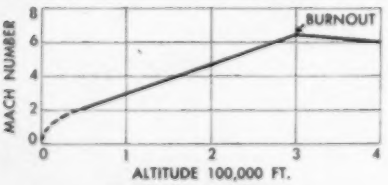
• **Many materials** that will fail completely in a few hours under high-temperature load conditions will hold their structural integrity well enough to serve out a useful life that's measured in seconds, or, at the most, a couple of minutes.

A satellite-launching vehicle is a good example of designing to such a specific operational requirement. Insofar as materials are concerned, life is so short, concern is more with melting point than it is with how many hours it takes for creep, warp or buckle to result in failure.

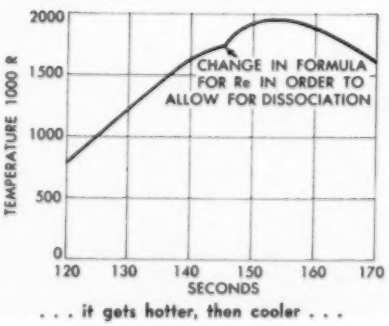
The roughly Mach 5.0 velocity that will take the 20-pound sphere through the lower atmosphere on the way to its orbit will subject the pointed tip of the rocket to some 2,700° F, compared to a platinum melting point of 3,223° F. The peak skin temperature aft of the tip during this escape will be about 1,500° F, compared to stainless steel's 2,760° F melting point. And at 300,000 feet the nose cone temperature will have dropped to 1,300° F and that of the skin down to about 1,200° F. And there, for the satellite, the temperature problem ends. It's only on re-entry that it would become hypercritical.

How Satellite Launching Vehicle Climbs Through Relative Coolness of Outer Space

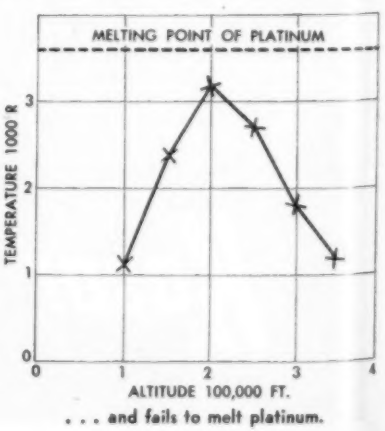
These three charts show that in an "escape" problem, aerodynamic heating is a relatively small worry. The charts, developed for a typical firing in connection with research during the International Geophysical Year, show how a satellite launching vehicle . . .



. . . goes higher and faster . . .



. . . it gets hotter, then cooler . . .



. . . and fails to melt platinum.

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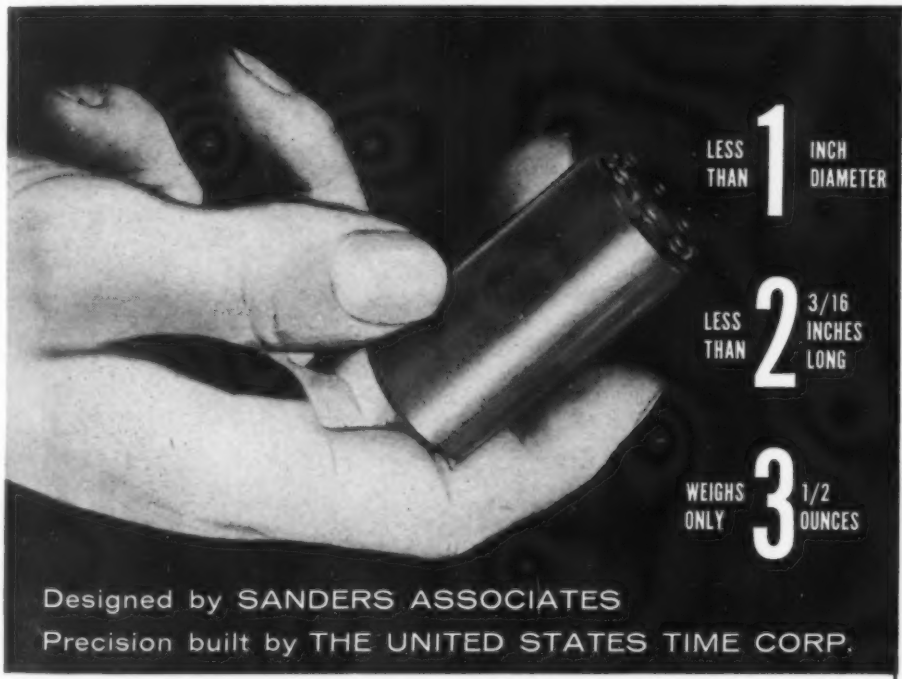

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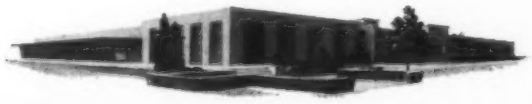

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New Techniques of Using Honeycomb

• **Today's task** in the case of aircraft is one of designing to long life at relatively moderate velocities and temperatures. The target for following generations is to increase speed and temperature without reducing the time factors. In some ways, even in extreme cases, the missile problem is less difficult to overcome than that of manned aircraft.

The higher the time-temperature-strength relationship required, the less designers can rely on proven knowhow and the more they must revert to intelligent "guesshow."

For example, we haven't seen detailed design specifications of the X-15 being made by North American, but it's generally billed as a "substantial step up" from the Bell X-2, a Mach 3.0, over 100,000 feet aircraft.

X-15 estimates range all the way from Mach 5.0 and 200,000 feet to Mach 10 and 150 miles.

• **An aircraft** going Mach 5.0 at 100,000 feet would raise the temperature of the air passing over its surface to more than 2,000° F. At Mach 10, at that altitude, the stagnation temperature of the air at the tip would be on the order of 8,000° F, and maybe 4,000° F a little way back, having been lowered by dissociation of the air molecules.

This same vehicle going Mach 10 at 150 miles would encounter virtually no aerodynamic heating, due to the thinness of the atmosphere at that altitude.

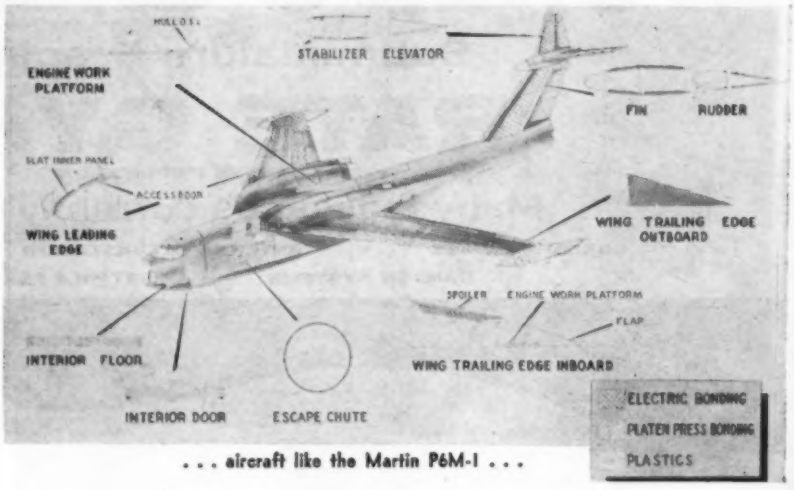
Re-entry Problems

Wherever its performance falls within this range, it will have to be planned and built virtually as a space ship, for it will, more or less, be faced with re-entry problems on the same order as those encountered by the ICBM.

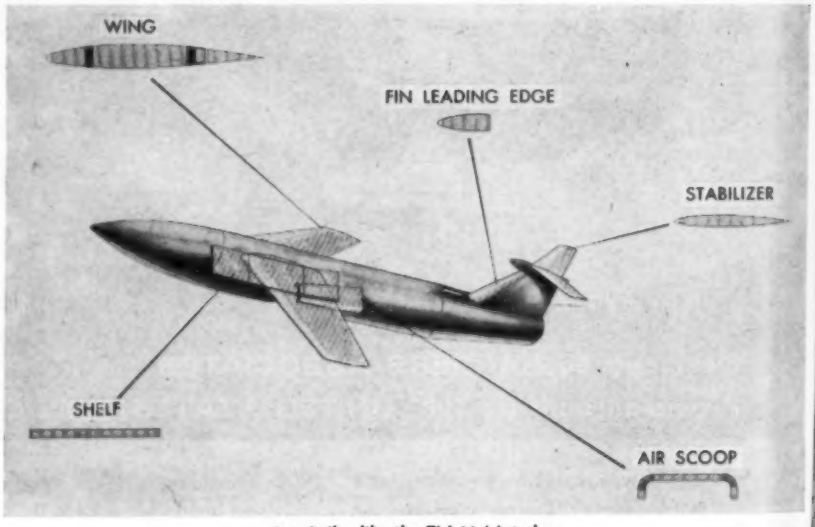
• **This means** it will probably have a structural skin not now familiar to the bulk of the aircraft industry, such as ceramic coated nickel-cobalt alloys, or platinum-plated molybdenum.

Heat will be coming in at such a rate it will be impossible to draw it away entirely. In flights of more than even a brief moment, the simple concept of the heat sink will not begin to provide an answer.

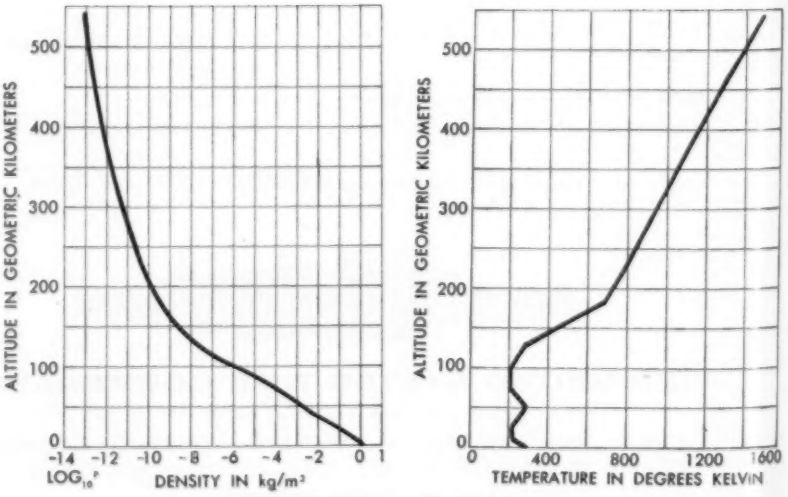
Ultimately it may be necessary to resort to fuselage nose cone and aerodynamic leading edges that have a built-in system of progressive, calibrated deterioration, utilizing materials that sublime at the high temperature conditions and use up heat doing so. This is one of the more promising solutions, under study for the ICBM warhead.



. . . aircraft like the Martin P6M-1 . . .



. . . in missiles like the TM-61 Matador.



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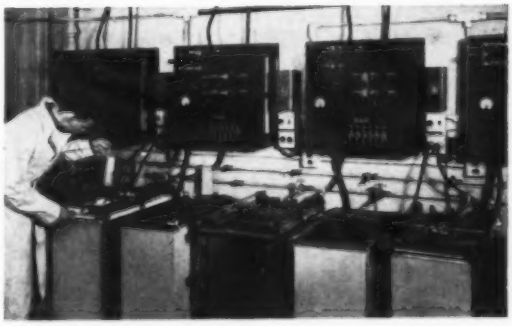

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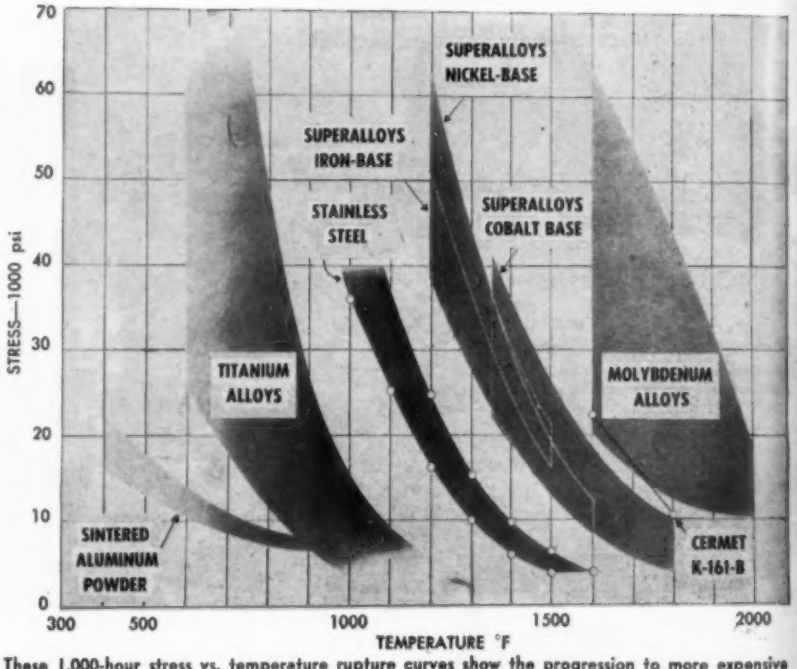
High-Speed Heat: Answers are Elusive

The first shock the designer gets when he first comes up against high-temperature flight problems of any kind is that he can no longer reach out and grab great hunks of cooling air to take the heat away. It's the air that's hot, and heat won't run uphill.

The second blow to his tranquility probably comes when he discovers that the higher the time-temperature-strength accountability of the materials offered for his consideration, the more unsatisfactory they are to work with. Titanium and stainless steel, for example, are difficult and costly to role flat; molybdenum oxidizes if you look at it; powder metals have no ductility; ceramics even less.

He doesn't lack, however, for a variety of routes to explore. Trouble is that none, by themselves, seem to go very far—not right now, anyhow. And in terms of construction, maintenance and operational flexibility, they're all expensive and largely unfamiliar.

• **Basically, the three ways** to cope with aerodynamic heat in high-speed flight are: absorb it; give it back; and "stand up and take it." Actually, almost every design involves the first and last of these to a greater or lesser degree. The ideal solution is to figure out how to give the heat back before it does any damage. Unfortunately, however, this is also the most difficult to achieve.



These 1,000-hour stress vs. temperature rupture curves show the progression to more expensive materials, as aircraft operating temperatures go up.

Needed: Heat 'Sink'

Absorption is an easy out and, in the lower over-one Mach numbers, practical. It is, that is, if once the heat is absorbed it doesn't fry the pilot or make a molten malfunctioning mess out of the "little black boxes."

This implies there's got to be a place to dump and store the heat where it will do no harm—a heat sink.

This means a skin and internal structure to pull the heat from the surface at a fast rate and conduct it as directly as possible to where it will do the least damage and have the most room to accumulate. This is usually the fuel.

This calls for materials with high heat conductivity coefficients, but permits use of those with a low degree of temperature accountability. For if the heat isn't left on the skin to build up, it won't get very hot. The heat sink has extended the operational limits under which aluminum can continue to be used, a circumstance, incidentally, for which both the airframe and aluminum industries are thankful.

• **But the heat sink** is limited: by the total weight of fuel, its specific heat and by just how many degrees it can be safely raised. At moderate Mach numbers most aircraft will run out of fuel before they fill up the heat sink. But as speed or time in flight or both go up the heat sink's usefulness is quickly exceeded.

It works only so long as the heat doesn't come into the skin faster than it can be drawn away. Once input exceeds pull-away, the temperature of the skin begins to rise and will, in time, become equivalent to that of the outside air. Under these conditions the heat sink, though still helpful, no longer is an end in itself. It needs help.

A thin wing going Mach 6 at 40,000 ft. would be absorbing heat at the rate of 74 BTU per sq. ft. per second. Massive, closely-packed banks of tungsten (filamented half-inch quartz tubes with a rated capacity of 200 watts per linear inch are used in laboratories to pattern and slam simulated aerodynamic heat into aircraft and missile components at a rate of 100 BTU per sq. ft. per second. The fact that these are already proving too low-powered for much present research gives a good idea of the extent of the problem. Now induction heating is coming into play for this purpose.

The ideal way to give the heat back to the atmosphere is to let the temperature of the vehicle rise to that point where the body radiates as much heat as it takes in. This is the equilibrium temperature. Unfortunately, it usually means getting red hot and can create more problems than it solves, particularly for manned vehicles.

But from Mach 4 or 5 up, dumping heat back in one way or another is the only way seen now to maintain any kind of sustained flight.

• **Transpiration**—exuding vaporizing, thus cooling liquids through a porous skin—looks good at first. But there's trouble developing a structural material that will maintain its stability (pores that won't clog or otherwise close up).

How to crowd enough fluid to do any good in today's packed and jammed weapons systems still hasn't been figured out.

Next, there's a half-heat-sink, half "give-it-back" proposal calling for early and close cooperation between engine and airframe maker. Briefly, it routes the fuel via tubes along the under side of hot skins and uses aerodynamic heat to vaporize and pressurize the fuel just

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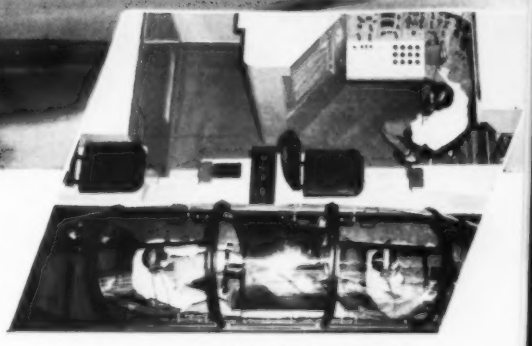

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AN 80-15	385
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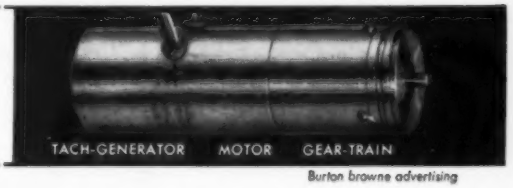

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before it enters the combustion chamber. At least one major aircraft company is toying with it.

'Give-It-Back' Technique

The "give-it-back" technique that's getting the most interest, however, is one that's closely related to the "stand-up-and-take-it" approach. It will probably play a vital role in beating heat at ultra-to-hypersonic speeds. This is sublimation. Similar in basic principle to transpiration, it relies on the latent heats of change of state and temperature rise to return the heat to whence it came, but uses structural solids instead of liquids.

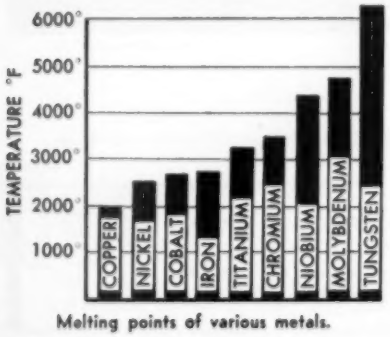
It entails construction of the hottest parts—nose cone, air foil leading edges, etc.—of a solid material that will sublime, i.e., go directly from solid to vapor without melting.

Some metals that sublime under high-temperature, high-pressure conditions include tantalum, tungsten, molybdenum and the noble metals like platinum, palladium, gold. The latter also have the added advantage of high polish (reflect heat), high chemical stability (won't oxidize) and high melting-vaporization points. For these reasons, they are hot contenders for ICBM cladding, an expensive solution that may actually cost less in the end.

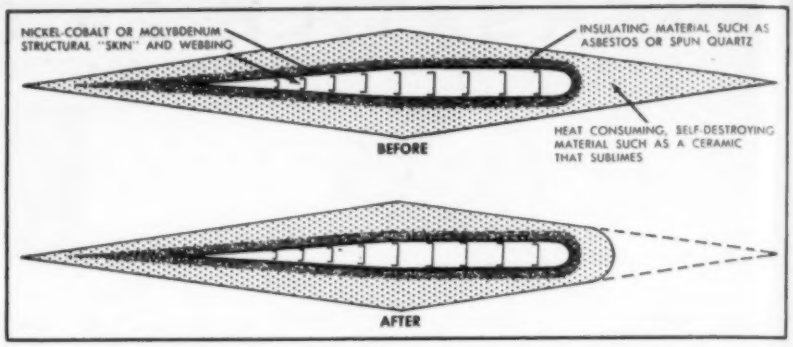
• **Hypersonic wind tunnel tests** show that deterioration of a structure by either sublimation or melting is repetitive in successive tests. That is, it is possible to predict under set conditions just how a component will deform as hot structure is vaporized away.

Translate this theory into a hypersonic manned interceptor that streaks up and out like a missile, takes one shot (probably with more hypersonic missiles) and then scuds quickly back to base. The nose cone and wing and tail plane leading edges would sublime away in such a manner that once the bullet-like outward flight was over, the areodynamic surfaces remaining, though no longer high-speed, would still be clean enough to enable the pilot to make a slow return.

On the ground again, the diminished parts would be removed and dis-



Melting points of various metals.


NICKEL-COBALT OR MOLYBDENUM STRUCTURAL "SKIN" AND WEBBING
INSULATING MATERIAL SUCH AS ASBESTOS OR SPUN QUARTZ
HEAT CONSUMING, SELF-DESTROYING MATERIAL SUCH AS A CERAMIC THAT SUBLIMES
BEFORE
AFTER

Hypothetical high-speed airfoil section showing shape before hypersonic intercept and after sharp leading edge has sublimed away in using up heat. The configuration remaining would permit low-speed return to base. Cross-section has been thickened to show detail.

patched for rebuilding after a single use, and new ones installed in their place.

This may sound crazy now, but it's on the books as a possible operational requirement. Basic research towards its realization is closely coordinated with that for the ICBM and Intercontinental Glide Bomber (unmanned).

• **A more immediate** practical requirement, however, is to design planes that can stand up and take it better, that can safely get a lot hotter than those of aluminium, but still not involve any radical departures. This grubby, unromantic but still challenging task is what primarily occupies the time of today's designers. Basically it means new materials. Some aircraft, for example, will be as much as 80% steel and titanium.

Next will come nickel-cobalt metals, like inconel, which will begin showing up in airframe skins and structures, and after that, less well-known materials like molybdenum or possibly tungsten, which has the highest melting point of any of the common metals.

And then there's the final step before giving way to "last resort" solutions such as sublimation, melting or even burning, heat resistant coatings such as ceramics. Somewhere early along the line the need to insulate the exterior skin from the working innards will bring into play laminates of spun glass, asbestos, spun quartz and dead air spaces such as those achieved now with honeycomb construction.

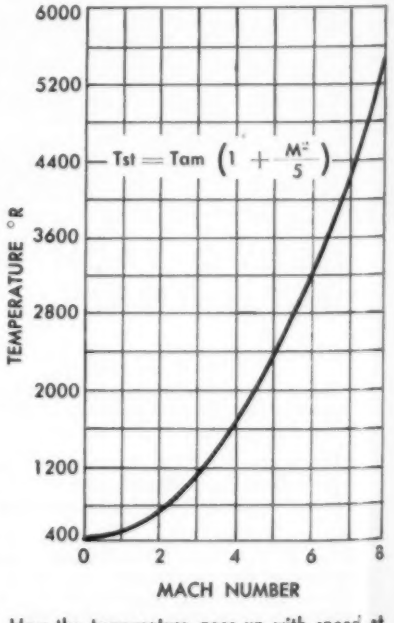
Material Characteristics

In designing for this next stage, the structural engineer's worst problems result from the nature of the materials he must work with. They come in a smaller selection of shapes and sizes. Tolerances are rougher. Ductility is usually less than that of aluminum. Cold riveting is no longer any good; even hot riveting has limited applications.

Traditional welding and brazing techniques were never intended for such operating temperatures. Nobody's bothered yet to install a mill to roll stainless steel or titanium into tapered sheet. The new materials are denser and therefore must be kept thinner to keep strength-weight ratios within bounds, and the advantages of bulk, such as the ability to carry column loads, are gone.

• **But perhaps the worst characteristic** of all is that the new tougher, higher temperature materials have very low coefficients of thermal conductivity. The heat stays and builds up where it hits, rather than tending to run quickly off to cooler parts.

In high-temperature flight, front parts are hot; those aft, cool. In between there's a sharp gradient. But metals (like other materials) have an awkward way of expanding with temperature, and in this case some parts try to expand more than others. Severe thermal stresses within the material



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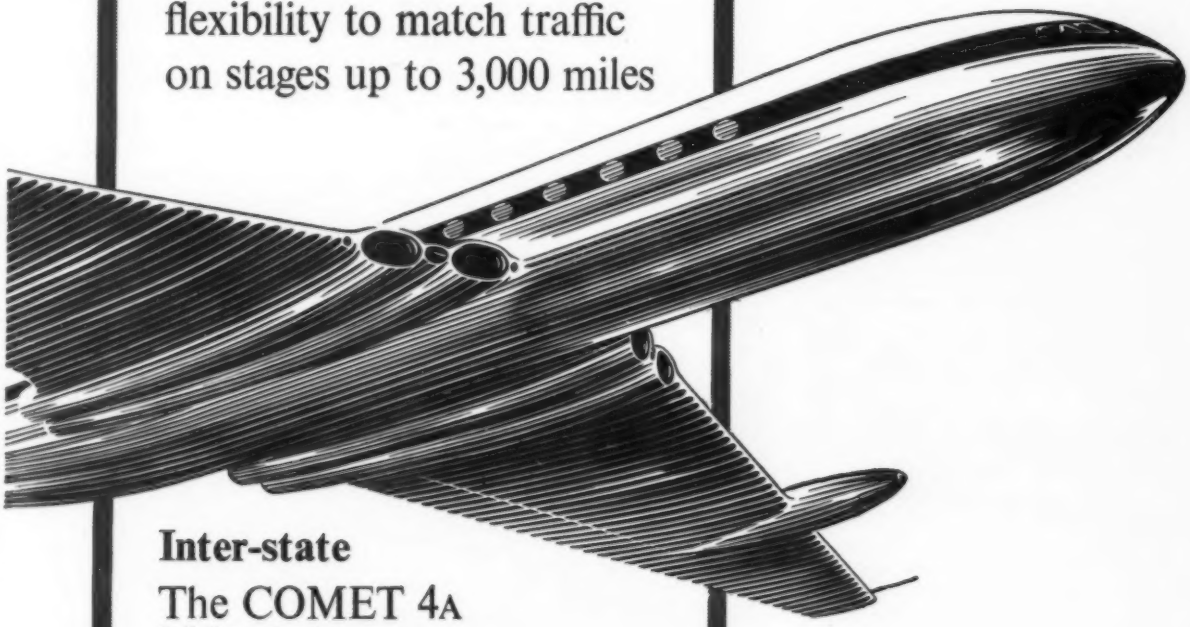

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result, hitting maybe 70,000-to-100,000 lbs. per sq. in. in a steel wing structure under Mach 3.0 conditions. This puts a real dent in the less-than 200,000 psi tensile strength that most currently available steels can offer.

Aside from outright failure, there's danger of buckling and other deformations causing catastrophic disturbance of the plane's shape.

Some methods of tackling this problem include addition of high conductivity materials to jump the heat from hot to cold spots; insulation of skin from internal structure; coating with non-structural materials such as ceramics that are nonstructural and more capable of coping with thermal stresses.

A considered but largely unexplored possibility is thermal preloading, designing for permanent plastic deformation of components. In this case the completed but unattached component would be heated to a point where plastic creep would allow imperceptible stress relieving deformations to occur. On cooling this would result in built-in counter stresses.

Another way of doing the same thing is to design in mechanical counter stresses to reduce thermal loads at temperature.

As yet another complication, the designer now has to cope with inescapable internal heat sources as well as hot air. No longer can he use the cool atmosphere to carry away the heat generated by the engines, electronic and other control equipment. New antenna coverings that won't go up in smoke or vapor are needed.

Sealing compounds and lubricants have temperature limits, too, and some now seem critically low. The designer can see quartz canopies running up to about 1,000°C but after that what—radar? At high temperatures, how does the pilot stay cool unless powerful but miniature air-conditioners are developed?

And all the while flight conditions and operational requirements demand that more and more paraphernalia be carried by the aircraft, the designer knows that one of the best and surest ways to reduce the heat problem is to cut down on frontal area.

• **But it's not all gloomy.** In many cases the engine designer now facing compressor inlet temperatures that a few years ago were thought impossible in the turbines in many cases "gets there" first. Though the problems are different, the airframe designer still usually can find something in engine knowhow that's helpful as each new stage is reached. He does, that is, except (as always) in the case of the ICBM.

Also as skin temperature goes up, it radiates more and more heat back into the air. This "emissivity" goes up as a fourth power of the temperature increase. Thus a black body at 500°K that emits heat at the rate of five horsepower per sq. ft., tosses it back at the rate of 400 hp at 1500°K. Also, as vehicles go faster, they're going higher, up towards the point of no aerodynamic heating. And time aloft, in many cases, is dropping.

But in the final analysis, there's scarcely a designer who's not hoping for a major technological breakthrough. Basic, complex mathematical theory indicates it may be possible to control heat with electric or magnetic fields. Maybe it will prove possible to catalize dissociation at much lower temperatures with the same 75% gain in temperature reduction.

Meanwhile, some researchers are studying meteors, the hypersonic missile that's been with us for ages. Others just wonder "Why don't we slow down?" ◈◈◈

Beating the Heat Costs Money, Mostly for New Tools and Knowhow

In the seemingly endless procession of hierarchial headaches associated with high temperature flight, probably the most painful and costly are those resulting from the chaos wrought on the factory floor.

Traditional methods and processes are now almost anathema. Machine tools either have to be rebuilt or replaced or, at best, their operating speeds changed and more carefully controlled. Even air may become taboo throughout long, complicated manufacturing sequences.

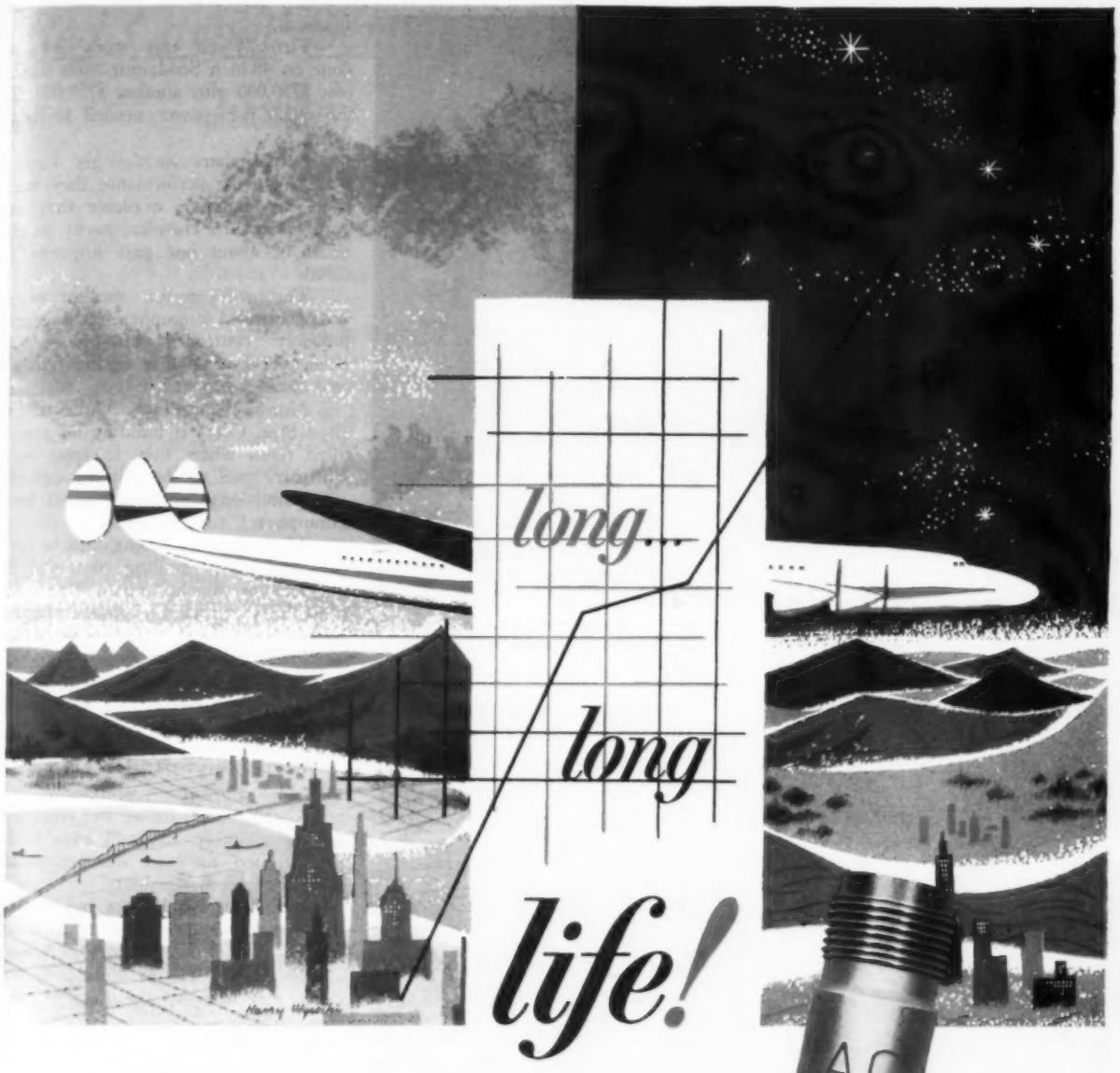
The list of changes now taking place on the plant floor plus those threatened is like the headaches—endless.

Cold riveting is virtually out for the denser, high temperature metals. Even hot riveting is limited in its usefulness. The switch is to brazing and welding at temperatures and under conditions of operational strength on which there exists very little background information.

As often as not, welding must be done in controlled atmospheres. Same with brazing, and equipment for brazing stainless steel honeycomb under a hydrogen atmosphere runs over $150,000 a copy.

New heat treatment temperatures range from -200° to over 2,000°F for stainless steel. As materials temperature accountability goes up, so will the

HOT RIVETING: A new airframe technique that's almost obsolete already.



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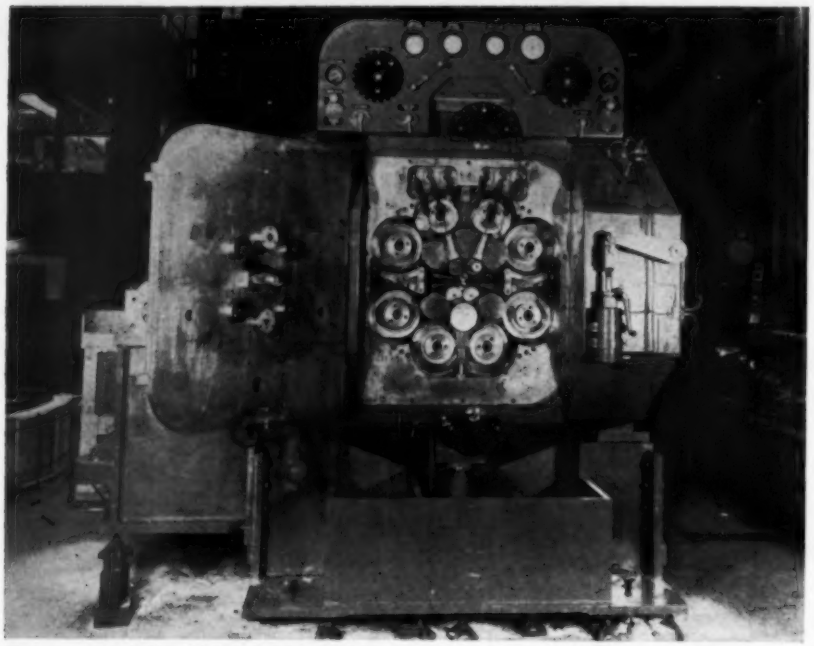
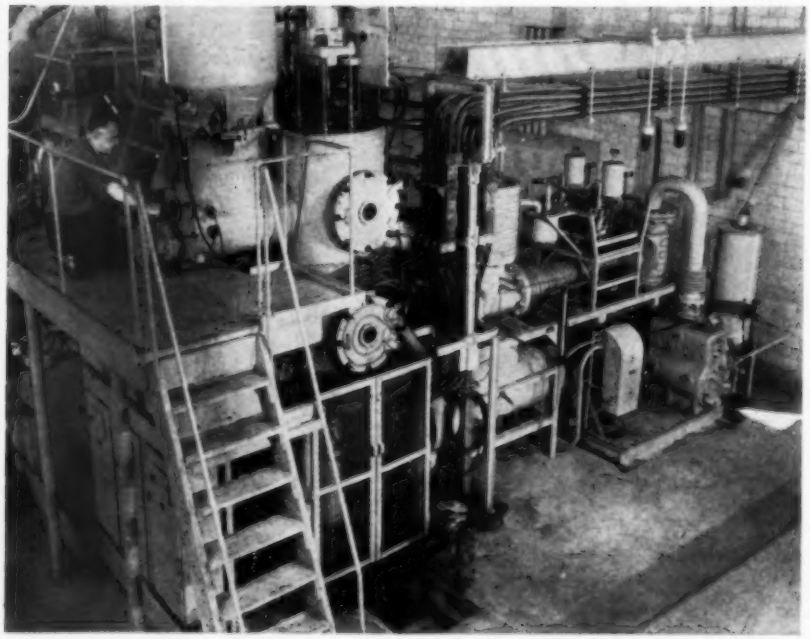


Business end of this 50" Sendzimir mill for rolling close tolerance stainless steel, titanium and molybdenum sheet shows one reason why these materials are so expensive. This unit with its power supply costs $1.5 million.



Equipment such as Climax Molybdenum Co's consumable electrode vacuum molybdenum furnace may be necessary in attaining the necessary purity and strength in new materials for tomorrow's aircraft.

temperatures required for heat treatment.

Machines that cut will require at least new harder cutting tools. Most will either have to have more power fed into them or be run more slowly. Many will simply have to be replaced as cutting speeds up to 10,000 rpm are called for.

Some machining times will increase 300-fold.

Chem-milling (chemical etching instead of actual cutting to machine parts) becomes increasingly attractive for a wide range of operations.

Conventional rolling mill equipment simply won't produce the necessary sizes and tolerances in steel and titanium.

Virtually all this work is now done on 48-inch Sendzimir mills which cost $750,000 plus another $750,000 for the 6,000 horsepower needed to drive them.

• **Researchers** increasingly suspect that to get the performance they want from the materials available they are going to require chemical purity on the order of about one part impurity in 6,000.

This will require vacuum or at least controlled atmosphere melting, and probably controlled atmosphere all along the process line to the finished cold sheet.

Along these lines, Universal-Cyclops Steel Corp. is building an argon-filled room where men in space suits will carry steel all the way through the fabrication stage in a simulated inert atmosphere.

There is an increasing shift to spar, skin and profile milling controlled by magnetic or punched tapes. Tolerances must be vastly closer; process control, tighter.

Plastic bonding can now be carried to 500°F, but beyond that new methods will have to be developed for the laminated build-up of tapered sections.

More Prefabrication Likely

More and more components that now undergo final fitting and trimming on the assembly line will have to be prefabricated to exact dimensions for complete interchangeability.

Initially, each sheet or rod or tube of new and previously untried materials will have to be checked for dimensions, tolerances and strength, until both producer and user become familiar with the product.

And, inevitably, as process changes come into being, the men on the plant floor expected to perform them will have to be trained to a higher degree of skill and responsibility than ever before. This means extensive on-the-job training programs.

This is the sort of thing that's in prospect with the coming shift from one metal to another. Ultimately there will be some cases where the change is to non-metallic materials, such as ceramics, where the alteration in method will be even more severe.

It's all expensive, but in the past man, through the changes wrought by progress, has always in the final analysis managed to get a lot more performance for relatively little more effort and money.

In this case there is no reason why the future should provide any exception, no matter how awkward and upsetting the current period of change may seem.

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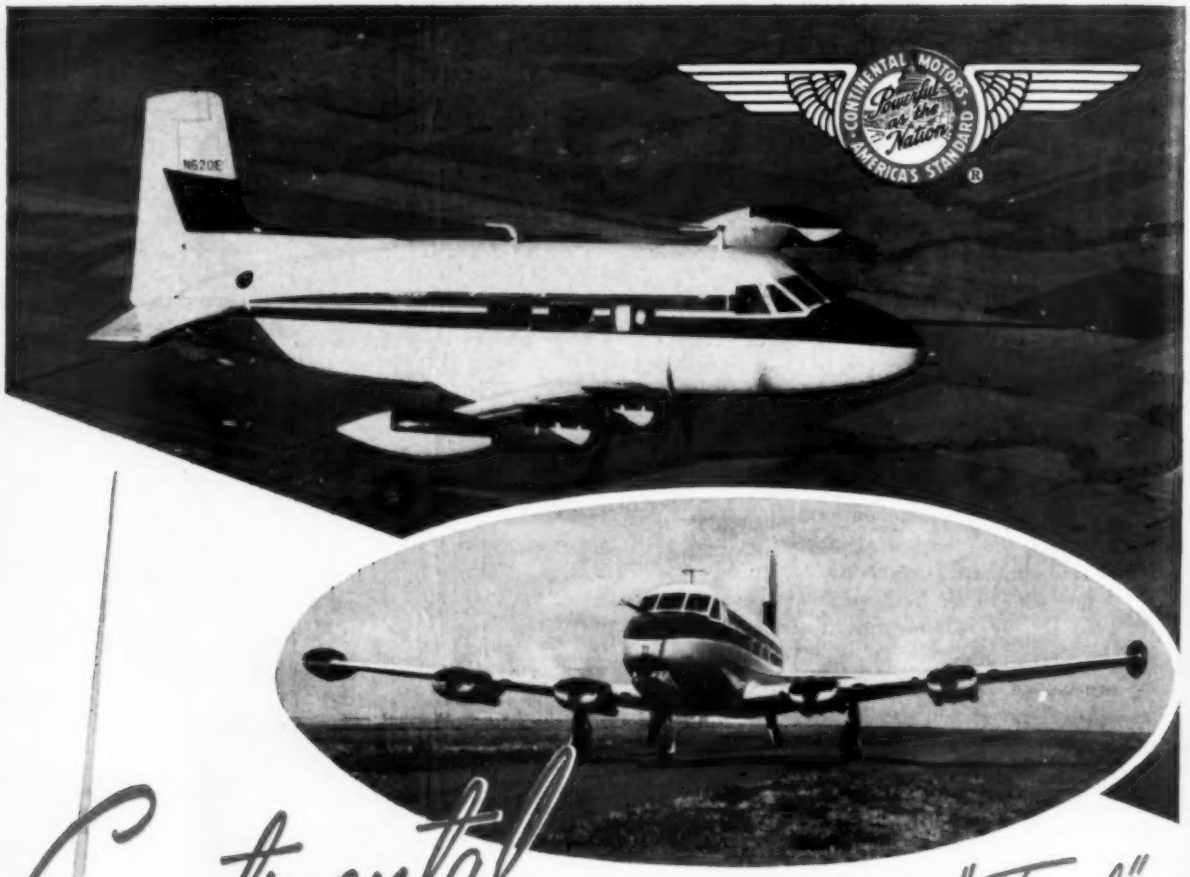

Continental Shares in Another Aviation "First"

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Two organizations long noted for their contributions to flying have joined hands to achieve another major aviation "first," Cessna's Model 620, now flying. . . . The Cessna Model 620, world pioneer of its type—first pressurized four-engine airplane built for the corporate market—unites several qualities which users of executive aircraft have long desired. Its four Continental Red Seal GSO526-A engines provide four-engine safety, with the important plus of Continental dependability, economy and service backing. It is pressurized for altitudes up to its four-engine service ceiling of 27,500 feet, and air-conditioned for comfort aloft and on the ground. . . . Flights climaxing three years' work on this advanced airplane have fully borne out its builders' highest expectations. The Cessna 620 now takes its place as the latest on the long roster of fine utility aircraft using dependable Continental power.

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Why Present Windtunnels are Inadequate

By ANTHONY VANDYK

The No. 1 challenge to windtunnel designers today is the hypersonic regime. Although there are several hundred windtunnels throughout the world only a handful of them are suitable for carrying out tests at hypersonic speeds, those above Mach 5.

The problems of hypersonic testing are so great that the conventional tunnel is no longer adequate, and alternate test facilities such as shock tunnels, shock tubes and mass accelerators come into the picture.

• **Why does** the hypersonic regime represent such a problem? To answer this question it is necessary to recall that, as the upper limit of the supersonic regime (Mach 5) is approached in the windtunnel's nozzle, unheated air starts to liquefy.

Air liquefaction can be retarded by the use of heat but the amount of heat required for even the lower hypersonic speeds is such as to induce other problems, notably tunnel expansion. As the high temperature reaches the test second the walls expand and, changing the area ratio of the nozzle, also change the Mach number of the stream during the run.

Other Gases Needed

It is possible to obtain fairly satisfactory results with conventional-type hypersonic tunnels up to about Mach 9, with air as the gas heated to about 1,300°F.

Above this figure, however, it is necessary to use gases other than air—helium, for example—which can be stored in a tank under pressure and feature a very low condensation point. Even then it is not possible to simulate important real gas effects with a conventional-type tunnel far up into the hypersonic regime.

Consequently the trend is away from the windtunnel to the shock tunnel. Here the main penalty is that each test run must be very much shorter—a hundredth of a second—than that in the conventional tunnel. Even so it is considerably longer than the run in a shock tube.

The prime example of a shock tunnel is the Mach 16 facility recently placed in operation at Air Research & Development Command's Arnold Engineering Development Center, Tullahoma, Tenn. This is how the Arnold shock tunnel works.

Air is first pumped into a storage chamber and sealed off from the downstream portion of the tunnel by a light, plastic diaphragm. The sealed area downstream of the diaphragm is pumped down to a vacuum condition (about one-millionth of an atmosphere). This serves to accelerate the airflow once the diaphragm is broken and the high pressure air flows down through the test section.

Next, a powerful electrical charge is triggered into the upstream air storage chamber. Instantly this electrical current of more than a million amperes heats the air to temperatures of approximately 15,000° and increases the pressure to approximately 20,000 lbs. per sq. in. This heated air under tremendous pressure breaks through the thin plastic seal and a stabilized but extremely high speed flow of air passes through a conical nozzle. The nozzle increases the velocity of the airstream just before it strikes the model mounted in the 16-in diameter test section.

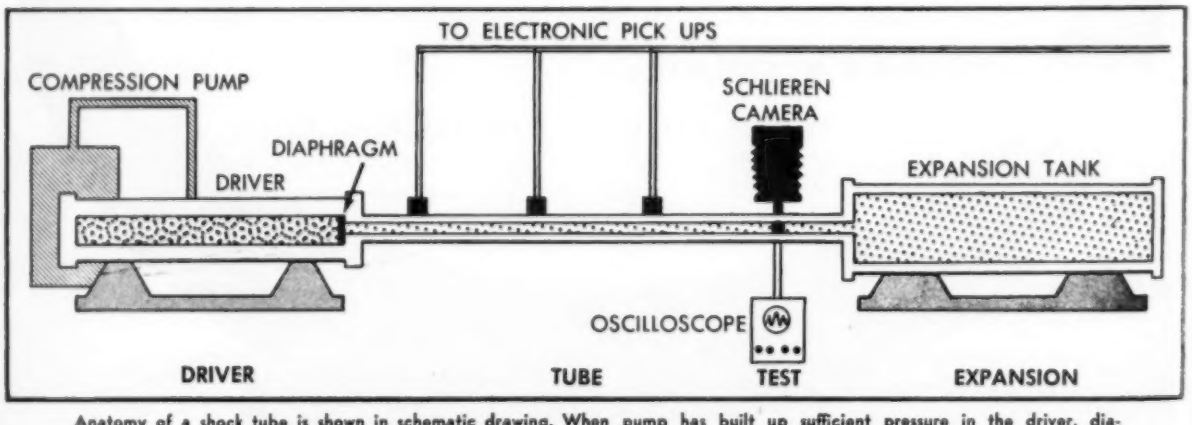
The electrical discharge actually melts away portions of the tunnel ducting and bits of glowing, molten metal strike the model during the latter phases of the airflow. However, this contamination develops later than it normally does in shock tubes, and is preceded by a longer, more uniform flow in which valid test data may be recorded.

Shock Tube Capabilities

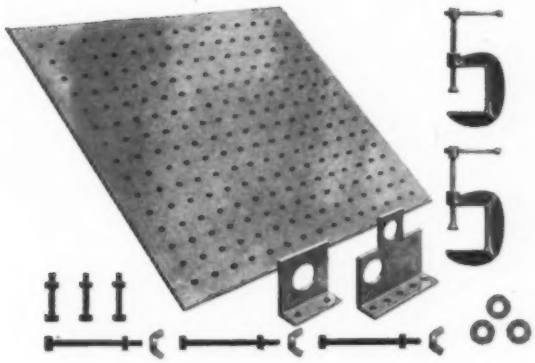
• **The shock tube** is able to reproduce speed higher than those simulated in shock tunnels. Only recently has detailed information on shock tube development become available. Avco Manufacturing Corp. recently revealed information on its shock tubes at the Avco Research Laboratory at Everett, Mass.

One of the six tubes at Everett is believed to be the largest hypersonic research device of its kind. Capable of simulating conditions at speeds up to Mach 25, this tube is more than 100 ft. long and has an inside diameter of four inches. The entire device is mounted on railroad-type tracks. This is how the shock tube works.

The tube is activated by the extreme compression of a mixture of gases, by the explosion of a combustible mixture of oxygen and hydrogen tempered by the addition of nitrogen and helium, or by the heating of a low-pressure combination of gases. In all cases, the reinforced rear section of the apparatus, known as the driver, is filled with gases under pressure and the rest of the tube, separated internally from driver by a



Anatomy of a shock tube is shown in schematic drawing. When pump has built up sufficient pressure in the driver, diaphragm ruptures and shock waves pass through tube to test section and on to expansion tank which absorbs force of firing.



Jigs, made from miscellaneous hardware like this, enable Honeywell Aero technicians to build temporary tooling in minutes at one-twentieth the cost of standard type fixtures. These so-called "erector set" jigs are used for short-run items, test fixtures and preliminary tooling. The idea, developed in the production department, is typical of the flexibility and imagination encouraged and rewarded at Honeywell Aero.

AERONAUTICAL DIVISION, MINNEAPOLIS-HONEYWELL

strong metal diaphragm, has almost all the air withdrawn from it.

When, through ignition, pumping, or heating, the pressure in the driver is high enough to burst the diaphragm, the metal plate ruptures and the gases and shock waves speed down the tube with the photographic equipment and instruments in the test section near the other end recording. The pressure of the gases and the force of the shock wave are dissipated when they reach the expansion tank at the end of the tube, beyond the test section.

• **Avco Research Laboratory's** four-inch shock tube can withstand temperatures ranging up to 20,000°F. Because of the very high temperatures involved the tube is in operation for only a millionths of a second or so. Pressures attained in order to burst the diaphragm range from 2,000 to 10,000 lbs. per sq. in.

Hypersonic test facilities are mainly used for missile research work. Another related facet of present-day wind tunnel development is connected with missile powerplants. In recent years there has been a rapidly increasing demand for engine test facilities.

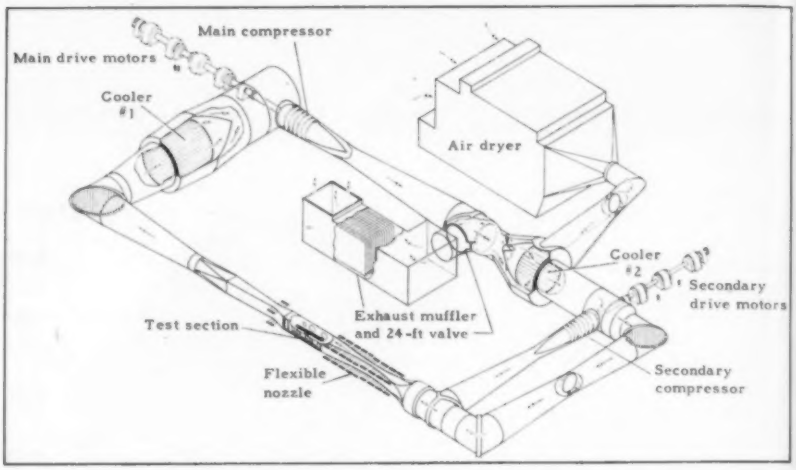
One of the latest windtunnels for such purpose was put into operation this year at the NACA Lewis Flight Propulsion Laboratory, Cleveland. Turbojet and ramjet operating conditions at speeds ranging between Mach 2 and 3.5 at altitudes of up to 30 miles can be simulated in the 10-ft.-square test section at this facility.

• **The Lewis tunnel** may be operated either in closed circuit, for aerodynamic tests, or in open-end propulsion circuit, with engines running under combustion tests. Its main purpose is to investigate such problems as engine inlet and outlet geometry, engine matching and interference effects, and overall drag.

The tunnel's 250,000-hp. electric-motor drive is one of the most powerful of its kind in the world.

Engine test facilities are strongly featured in the USAF's Arnold Engineering Development Center. The officially named "Engine Test Facility" (ETF) and the "Propulsion Wind Tunnel" (PWT) are already in part operation while the "Ramjet Addition" (RJA) is due to be ready for use next year.

The ETF is for development and evaluation testing of aeronautical air-breathing propulsion systems. It is adaptable for a variety of propulsion unit testing programs, and can be used for test work on turbojets (with or without afterburners), ramjets, turboprops, pulsejets, turbofans, combined-cycle engines and for engine inlet and nozzle configuration tests. It can test engines at altitudes up to 60,000 ft., at temperatures ranging from minus 120°F to plus 650°F, and at speeds from Mach 2 to 3.



Schematic drawing shows main elements of NACA Lewis Flight Propulsion Laboratory tunnel, a Mach 3.5 facility recently taken into use. It is driven by a 250,000-hp electric motor and has a 10 ft. by 10 ft. test section.

The engines are locked into 12½-ft.-diameter sealed test cells which can be varied in length from 32 to 90 ft., then "fed" intake air conditioned to simulate the desired altitude and temperature and at a mass airflow rate which permits running the powerplant at the desired Mach number. Ramjet engines have been tested at ETF in a special water-jacketed test cell, which has a specially designed, free-jet nozzle 26-in. square, that also permits testing with variable angles of attack.

All of ETF's test cells can be used to test engines by "direct connect" means in which all of the intake air is rammed into the inlet of the engine. In one of these cells, however, engines can be mounted for "free jet" testing in which the air surges around the engine as well as into its inlet. Another cell can be modified for this type testing if required. Different angles of attack can be arranged for in both the direct and free-jet set ups.

• **An unusual piece of equipment** conceived and designed by ARO Inc., operating contractor for the Arnold Engineering Development Center, makes possible the simulation of complete flight trajectories for supersonic ramjet engines without the need for actual flight testing of the engine.

By simultaneously varying the Mach number and angle of attack of an airstream directed into a ramjet engine enclosed in a sealed test cell, an engine may be operated through the same sequence of conditions as it would encounter in all operational flight conditions by the use of a variable supersonic nozzle.

The nozzle is basically of the two-dimensional rotating-block type and consists of two flat walls and two adjustable contour walls which are symmetrical about the centerline. Each contoured wall consists of a machined block which includes the subsonic approach and the supersonic expansion section with a rigidly-attached flexible plate which extends from the region of the inflection point to the nozzle exit where it is restrained from rotating but allowed to move axially.

This simplified mechanism, with its nearly linear action, is easily controlled and permits very accurate positioning of nozzle walls without the necessity of elaborate positioning devices. At present, the throttle of the 26-in.-square nozzle is contollable to within one-thousandth of an inch by means of a mechanical counter and variable speed gear motor with jog controls.

• **The Ramjet Addition (RJA)** at Arnold is scheduled to start test work in 1957.

It will be able to test engines at speeds up to Mach 4 and at altitudes "substantially above 80,000 ft." by using the 60,000-hp. air supply and exhauster systems of the adjacent Engine Test Facility (ETF), and augmenting these with powerful compressors and exhausters of its own, the RJA will utilize almost 200,000 installed hp to simulate flight conditions for the large ramjet and turbojet engines.

Large heaters, coupled with the refrigeration and cooling equipment of the ETF, will be used to provide RJA's testing temperature range of minus 120°F to "substantially above 650°F."

One of the most unusual features of the laboratory is its design which will

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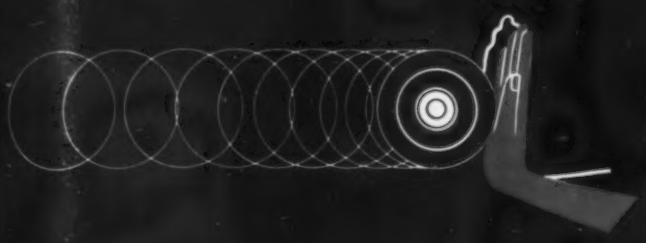

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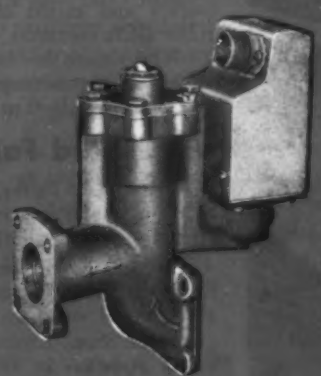

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provide for simultaneous variations of speed, altitude, temperature and angle of attack. For brief surges of very high speed, airflow, the RJA will be connected with a 720-ft. long high-pressure, air-storage reservoir of the nearby Gas Dynamics Facility.

This reservoir can store 50 tons of air at pressures of 4,000 lbs. per sq. in. Water sprays, using a flow of more than 125,000 gals. per minute, will be sprayed into ducting to cool the 3,000°-plus jet exhaust and disperse the jet before it is discharged into the atmosphere.

The Propulsion Wind Tunnel at Arnold has two, closed-circuit test sections, one for Mach 0.8 to 1.6 and the other for Mach 1.5 to 5. The former is already in operation. Altitudes up to 100,000 ft. may be simulated. The steel ducting of each circuit varies from 28 to 55 ft. in diameter.

• **The PWT's two circuits** have compressors driven by a 216,000-hp system comprising four electric motors. Two of these, are 83,000 synchronous motors, while the other two are 25,000-hp induction motors. All four motors may be used to drive either one of the two compressors, or the output be split, and both circuits can be operated simultaneously up to half the power output. A common shaft of 574 ft. connects the motor drive with the two compressor systems.

The transonic airflow is driven by a three-stage compressor. The supersonic compressor has an 18-stage system consisting of four compressor units in series. The rotor of the transonic circuit compressor contains 97 steel blades weighing 1,200 lbs. each and mounted on discs 18 ft. in diameter. They run at 600 rpm and centrifugal force exerts a pull of about 800 tons on each blade.

Airflow for both circuits is partially controlled by variable stator vanes in each of the compressors. To cool the airflow both circuits have water-cooled baffles inside the ducting. The transonic circuit has one cooler while two are required for the supersonic circuit. At maximum operation 100,000 to 150,000 gals. of cooling water per minute will be required.

The huge test facilities at Arnold and at the NACA establishments tend to dwarf the tunnels operated by aircraft manufacturers, universities and others. ◈◈◈

Northrop's New Supersonic Trainer

Artist's sketch of Northrop's new TZ supersonic trainer. TZ has very thin, short wing set low and far back on fuselage, which incorporates the area rule. Leading edge is swept and trailing edge has slight reverse sweep. Vertical tail is swept back from dorsal fin merging out of cockpit area and semi-swept low-set horizontal stabilizer has slight cathedral or downward droop. Tapered nose sweeps back into a slightly convex underline to give snout a somewhat upturned appearance. Twin engines are housed side by side aft of center line and partially in wing root area. (Sketch courtesy Los Angeles Times)

RAF Vulcan Crash Under Investigation

Production plans for the Avro Vulcan are unchanged pending completion of the investigation of the crash of one of the jet bombers on October 1. The Vulcan crashed at London Airport while attempting to make a GCA landing in bad weather (cloud base, 300-700 ft.; visibility, 1,500-3,300 ft.) on its return from a round trip to Australia. It had made the 4,000-mile flight from Aden nonstop.

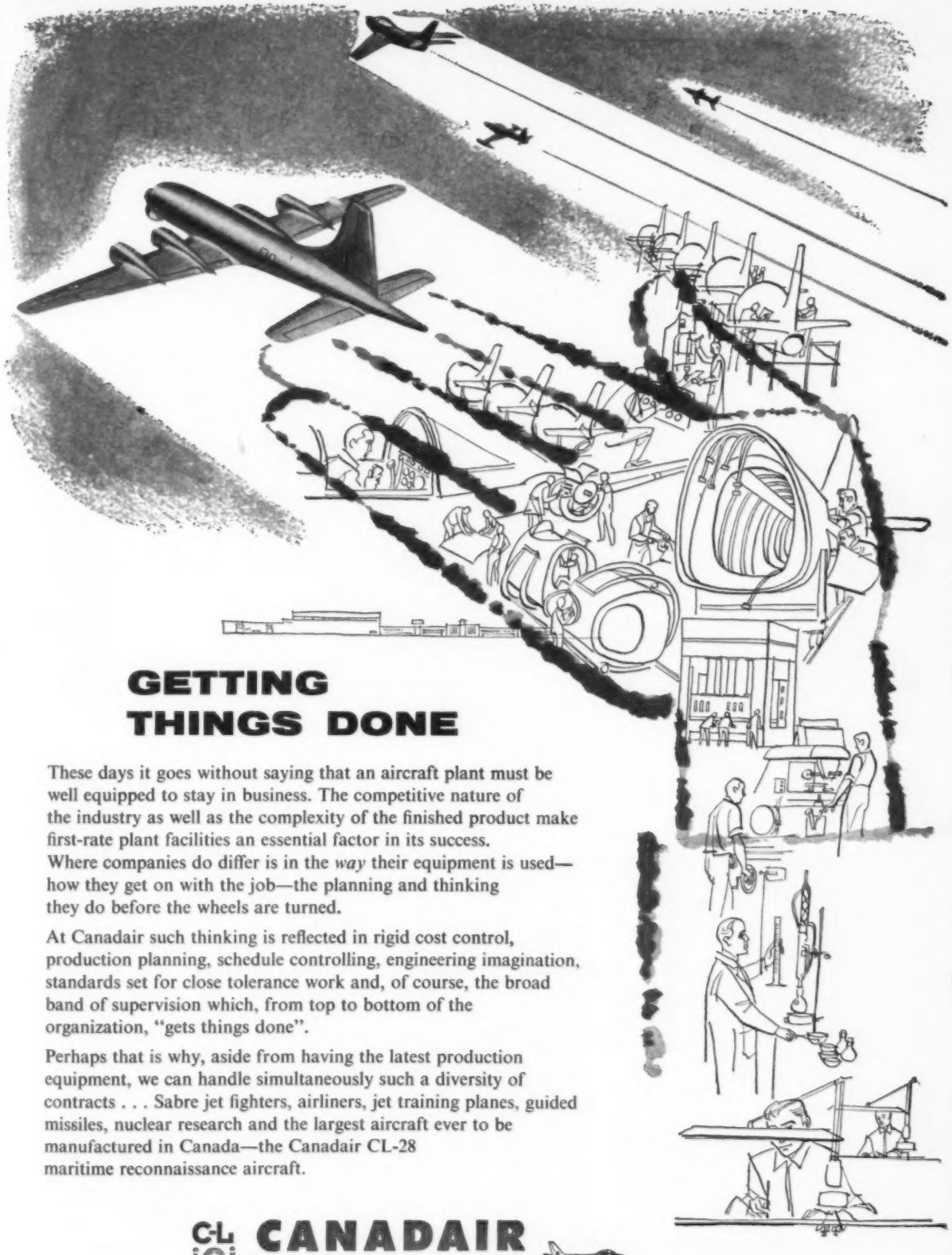
The pilot and Air Chief Marshal Sir Harry Broadhurst, head of RAF Bomber Command, managed to use their ejection seats but the other four crew members were killed. AMERICAN AVIATION London editor reports that the crash might have been caused by the high approach speed necessary with a tailless delta due to initial sink when rounding out for touchdown. This faster approach makes ILS markers pass quickly and might confuse an unfamiliar GCA controller.

The Vulcan lost height and hit the ground or obstructions before the runway threshold. It then stalled.

Sir Richard Fairey Dead

Sir Richard Fairey, 69, British aviation pioneer and founder of Fairey Aviation Co. Ltd., died in London Sept. 30.

Sir Richard served as manager of Blair-Atholl Aeroplane Syndicate in 1912-13, and was later named chief engineer of Short Brothers. He founded Fairey Aviation in 1915 and until recently served as chairman and managing director. The company is a major manufacturer of British naval aircraft and is also making missiles. The Fairey Delta II is international speed record holder.



GETTING THINGS DONE

These days it goes without saying that an aircraft plant must be well equipped to stay in business. The competitive nature of the industry as well as the complexity of the finished product make first-rate plant facilities an essential factor in its success. Where companies do differ is in the *way* their equipment is used—how they get on with the job—the planning and thinking they do before the wheels are turned.

At Canadair such thinking is reflected in rigid cost control, production planning, schedule controlling, engineering imagination, standards set for close tolerance work and, of course, the broad band of supervision which, from top to bottom of the organization, "gets things done".

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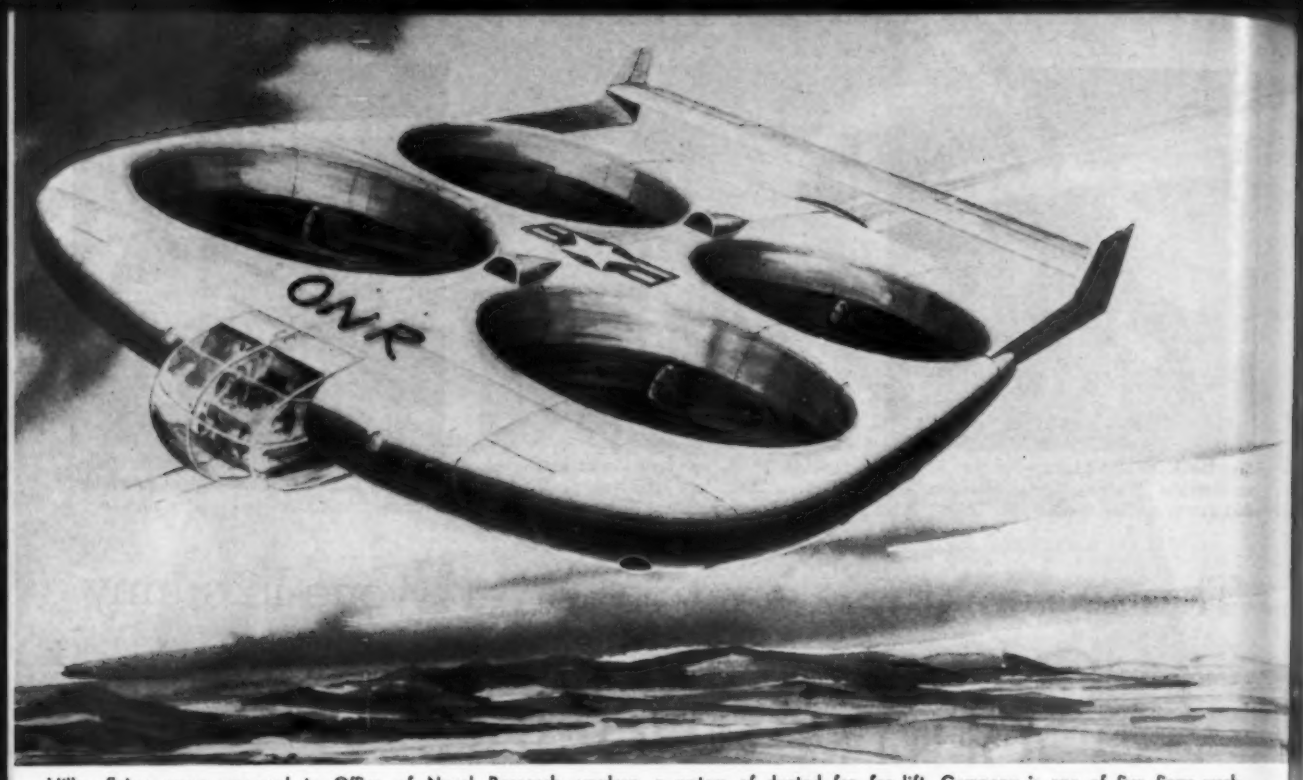

Hiller flying crane proposal to Office of Naval Research employs a system of ducted fan for lift. Company is one of five firms working on Army-financed studies of aerial cranes capable of hauling up to 16 tons of cargo for ranges up to 100 miles.

VTOL: Next Great Advance in Aeronautics?

Dozen firms working on development projects for Army, Navy and Air Force; tilt-wing, deflected slipstream, ducted fan approaches being tried.

By HENRY T. SIMMONS

Approximately one dozen U.S. aircraft companies—most of them small firms—are quietly plotting a prodigious technological advance in aeronautical development.

Their goal: Vertical takeoff and landing (VTOL) aircraft which do not employ the fixed rotor of the helicopter to secure vertical lift capability.

All the companies hold contracts with the Army, Navy or Air Force to develop various types of VTOL aircraft. Among them are such firms as Fairchild Engine and Airplane Corp., Ryan Aeronautical Co., Vertol Aircraft Co., and less familiar names like Doak Aircraft Co. and Transcendental Aircraft Corp. Altogether, their projects cover virtually the entire spectrum of potential VTOL vehicles.

The VTOL aircraft is regarded by many students of aviation as the next logical development in aeronautics. For the civil airlines, it is a way to escape the ever-lengthening runway and to provide more convenient service between city centers with greater safety, lower cost and better performance in poor weather.

For the military, the VTOL means freedom from extensive bases, ability to disperse to unprepared locations and, most important, the ability to operate from limited areas in enemy territory.

• **The principle** of the VTOL aircraft is by no means new. The helicopter is the first and certainly the most widely used VTOL now in operation. It is also the most efficient from the standpoint of pure vertical lift, since it can develop 8 to 12 pounds of thrust for each installed horsepower. But it has one major drawback: It is severely limited in the forward speed it can attain because of the drag of its huge rotor.

This shortcoming of the helicopter, together with the perfection of the turbojet and turboprop powerplants with their characteristic high power/weight ratios, has encouraged aircraft designers to seek alternative means of obtaining vertical lift characteristics without sacrificing forward speed.

Three Approaches

Perhaps the three most popular approaches from the standpoint of a cargo VTOL are the tilt-wing, the deflected slipstream and the ducted fan, all of which employ propellers to generate thrust. But turbojet-powered VTOL transports are also possible as well as jet-powered tail-sitter fighters resembling the Convair XFY-1 and Lockheed XFV-1 Pogo aircraft. Still more exotic VTOL examples are the coleopter or ring-wing aircraft and the flying platform, such as that developed by Hiller Helicopters.

• **K. S. Coward and E. R. Hinz,** Ryan design engineers, describe a VTOL which uses large trailing edge flaps to direct the slipstream from two propellers directly at the ground. It would have a design gross weight of 33,000 pounds, a design payload of 5,000 pounds, a top cruising speed of 430 mph and a range of 1,000 miles. It would be powered by two Pratt & Whitney PT2G-3 turboprop engines of 6,000 shaft horsepower, each swinging 19-foot propellers. Its wing would be 45 feet long and it would have an aspect ratio of about 4.

The beauty of this design, according to Coward and Hinz, is its flexibility. Should a take-off run be possible, it could boost its payload 50%

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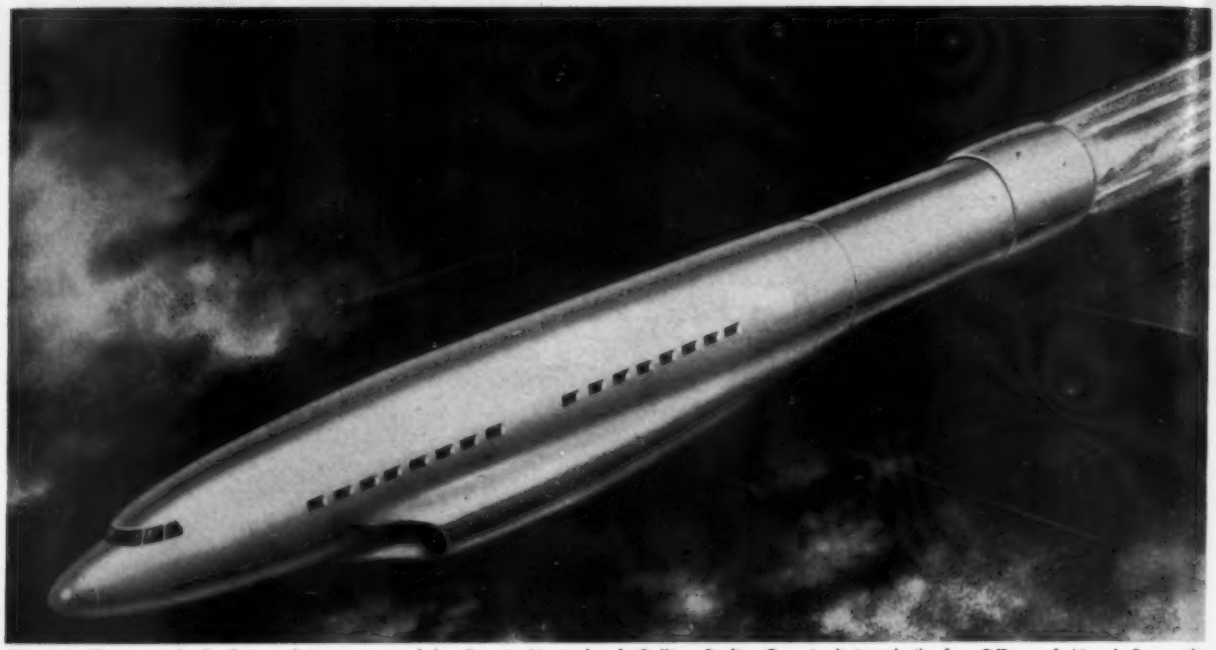


Two-man flying testbed of Aerodyne, conceived by Dr. A. Lippisch of Collins Radio Co., is being built for Office of Naval Research.

merely by making a 100 foot run into a 10 mph wind. If a take-off run of 500 feet is possible, it could boost its payload 140%. Thus it demonstrates a distinct short take-off and landing (STOL) capability where feasible.

• **R. J. Woods,** a design consultant for Bell Aircraft Corp., has discussed a ducted fan VTOL studied by Bell. Utilizing two rotatable ducted or shrouded propeller installations mounted in the wingtips, the design has a payload of 4,000 pounds, a maximum speed of 430 mph and a range of 800 miles, assuming a speed of 350 mph at 30,000 feet, with sufficient fuel remaining for 16 minutes of hovering. (See photo)

Like the Ryan design, it also has the ability to take on added payload or fuel where STOL operation is permitted. With a ground run of 400 feet, it can carry 3,500 pounds of overload fuel, increasing its range to 1,100 miles.

Woods also described a Bell design for a turbojet VTOL capable of very high speeds. Utilizing jet engines mounted in a conventional position beneath the wings plus the addition of auxiliary exhaust chutes to direct the thrust downward, the aircraft would be capable of a range of 800 miles at Mach 2.0, allowing for six minutes of hovering at the terminal. With a take-off run of 1,500 feet it could carry an overload of 30,000 pounds of fuel and extend its range to 1,300 miles.

• **The real key** to the VTOL is the powerplant, according to Charles H. Zimmerman of the National Advisory Committee for Aeronautics. An engine weighing more than two pounds per horsepower permits no useful load for a VTOL. But with powerplants weighing about three-quarters of a pound per horsepower, the useful load of a VTOL amounts to 25% of its gross weight or about half that of a conventional plane.

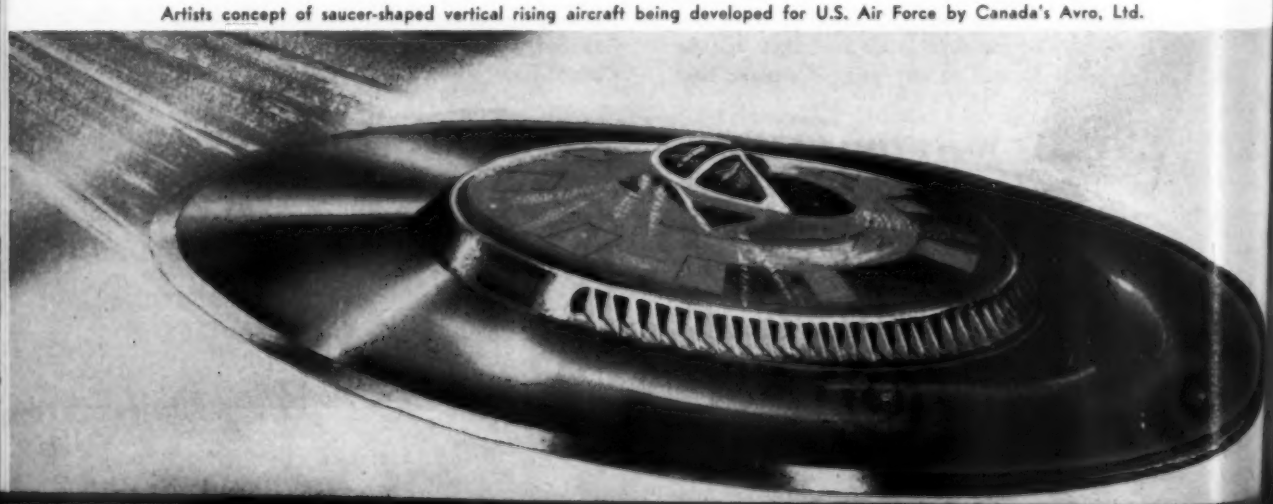
"As powerplant weight goes down, the penalty for VTOL also goes down. It is believed that at some point of the curve the further benefit of utilizing lower powerplant weights to provide greater ratios of useful load to gross weight (in conventional aircraft) will be less remunerative than using them to provide VTOL capabilities," he believes.

In this connection, Zimmerman points out that the penalty is substantially less in the case of a short take-off, vertical landing (STOVL) aircraft than one considered as a pure VTOL.

Lt. Col. Michael J. Strok, Chief of Army Aviation Research and Development, believes the VTOL will replace the helicopter as a significant Army vehicle within the next several years, although he does not feel the helicopter will be eclipsed entirely. As to whether its successor will be a genuine VTOL, or STOL aircraft, he observes:

"For the VTOL case, if specific weight of installed gas turbine power-

Artists concept of saucer-shaped vertical rising aircraft being developed for U.S. Air Force by Canada's Avro, Ltd.



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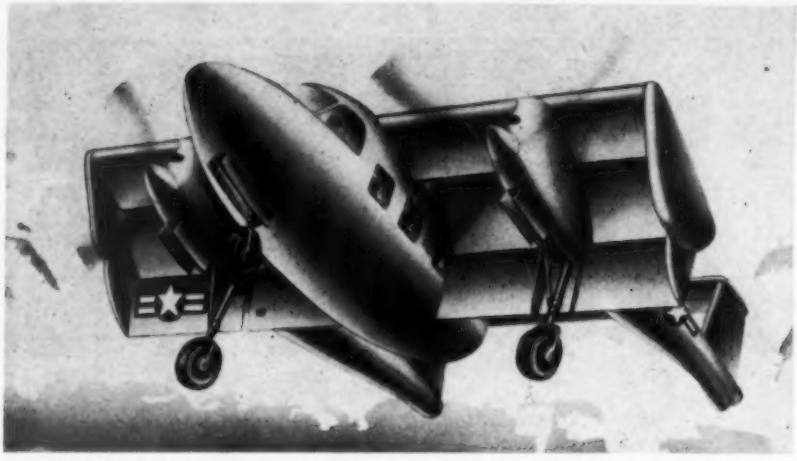

Ryan's deflected-slipstream will use Lycoming T53 turbines driving two large props.

plants and specific fuel consumption continues to decrease, this type . . . appears to have an operational advantage over STOL that may outweigh the economic factor of higher installed power and somewhat less favorable useful-to-gross weight ratio . . . For the STOL case, it may be desirable to have VTOL performance in the lightly loaded condition which would make the stability, controllability and power requirements of the two types comparable."

Flight Experience Needed

While there is wide disagreement among the experts as to what form the future VTOL will assume, practically all parties agree that the most urgent requirement at the present time is for full-scale flight experience with aircraft embodying the new principles. To this end, the military services have financed a total of 15 different projects involving construction and testing of VTOL prototypes and testbeds.

• **The magnitude** of the individual VTOL projects ranges from less than $1 million for most of the Army projects to $8 million or more in the case of USAF projects. In fact, there is considerable disagreement between the two services as to the best way to research the new VTOL field.

The Army contends that it can get four flying testbeds for just half the cost of a regular prototype, and that it can get the results it wants much faster. The Air Force, on the other hand, likes full scale prototypes and it argues that industry takes greater notice if a new aircraft—even though experimental in nature—is developed extensively.

The USAF is financing the following projects with its own funds:

• Ryan X-13 Vertijet—formerly a Navy project, the X-13 is a delta-wing tail-sitter powered by a Rolls-Royce Avon engine. Directional control is provided by small reaction jets in the wingtips. The machine has been tested successfully at Edwards AFB and reports indicate it has remarkably good stability and controllability in the hovering position.

• Bell X-14—also a jet VTOL using reaction jets for hovering control. It's believed the machine employs jet exhaust deflection.

• Hiller X-18—a twin-engine tilt-wing VTOL with a gross weight of 22,000 pounds. Employs two T40 engines made available by the Navy from its Lockheed Pogo project. Fuselage comes from a Chase C-122. A new wing will be constructed.

• Avro Saucer—Under construction for the Air Force by Avro Aircraft, Ltd., Toronto, Canada. Turbojet powered. (See photo.)

The Army is financing directly the development of two testbeds:

• Fairchild—VTOL using four Lycoming reciprocating engines and large flaps to deflect the slip-stream. (See photo.) Contract price is $1,007,087.

• Doak Aircraft Co., Torrance, Calif.—A $341,633 contract to develop a ducted fan VTOL similar to Bell concepts.

Acting jointly with the Office of Naval Research, the Army is supporting these projects:

• Ryan—A flying testbed embodying the deflected slipstream principle. Powered by a single Lycoming T53 turbine engine in fuselage linked to the propellers through shafting. Contract for $700,000.

• Transcendental Aircraft Corp., Glen Riddle, Pa.—A tilting rotor concept similar to Bell's XV-3 convertiplane, although much smaller. Company's initial model, built with its own funds, was destroyed. Second model completed and now undergoing test.

• Vertol—a small tilt-wing testbed powered by a single T53 mounted in the fuselage. Interconnected propellers are driven by shafting. To fly by mid-1957. Contract for $850,000.

• Hiller—small one-man flying platform employing ducted fan principle. Powered by 120-hp engine driving two contra-rotating blades six feet in diameter. Originally ONR, the project is now financed exclusively by Army.

• Collins Radio Co.—small two-man testbed based on the Aerodyne of Dr. Alexander Lippisch. Users recipro-

Ducted fan testbed of Bell-proposed VTOL is being built for Army by Doak Aircraft Co.

cating engine, two contra-rotating propellers.

Military Defense Assistance Program:

• Breguet 941—technically an STOL, it employs a deflected slipstream principle.

• The Pogo projects—Both Convair and Lockheed designed, built and tested turboprop fighter prototypes. These were the XFY-1 and the XFV-1. The latter project has been abandoned, while the former project is still active. Its principal purpose is to train pilots to handle aircraft in unfamiliar, tail-sitting attitudes.

During the course of development, the Convair XFY-1 successfully took off and landed in the tail-sitting position. The Lockheed machine successfully converted at altitude, but did not employ the unconventional position on takeoff and landing.

• The Convertiplanes—McDonnell Aircraft Corp. designed, built and tested the XV-1 under an Air Force contract placed on behalf of the Army. The XV-1 features a standard helicopter rotor for takeoff and landing and a pusher propeller for forward flight. During forward flight, the main rotor is unloaded.

A second Army-financed convertiplane, the Bell XV-3, is still undergoing tests. It utilizes tilting rotors mounted in the wingtips which operate like helicopter rotors during ascent and descent, but which may be swung forward into the conventional propeller position for high forward speeds.

Coleopter Possibilities

The services are also exploring the possibilities of the ring-wing propeller combination or coleopter. Both Piasecki Aircraft Corp., Morton, Pa., and The Kaman Aircraft Corp., Bloomfield, Conn., have Navy study contracts for work in this area. They could lead to hardware contracts.

Fairchild will build deflected-slipstream VTOL testbed using four piston engines.

Though intensive work in the VTOL field has barely started, some preliminary forecasts have already been advanced by those familiar with the radical new flying machines:

• The VTOL aircraft of the future—particularly in the cargo and passenger applications—will assume a conventional attitude on the ground. The tail-sitter configuration, while it may be adequate for fighter aircraft and other specialized military machines, is awkward from a cargo loading and unloading standpoint and demands excessive changes of attitude on the part of passengers. Furthermore the tailsitter does not have the inherent flexibility of those VTOLs which are capable of increasing payload by means of a takeoff run.

• Convertiplanes, in so far as they borrow rotary lift from helicopters, are not likely to prosper from a design standpoint because of the high drag induced by the rotors.

• The helicopter will probably remain in the picture, though with dwindling importance, as long as there exists a requirement to perform missions which require a large amount of time in the hovering attitude, such as search, rescue, sonar dipping and the like.

As to the exact form of the future VTOL aircraft, the experts disagree.

The great variety of technical possibilities makes this an impossible question to answer now. Suffice it to say that the rapid proliferation of VTOL concepts testifies to the great virility of the basic idea, and that the VTOLs which finally come to dominate the picture will be those which truly represent the best engineering compromise of many fruitful ideas. ◈◈◈

Transcendental's tilting rotor convertiplane (left); Bell Aircraft's XV-3 (right).

PROGRESS IN BALLISTIC MISSILES SPEEDS UP

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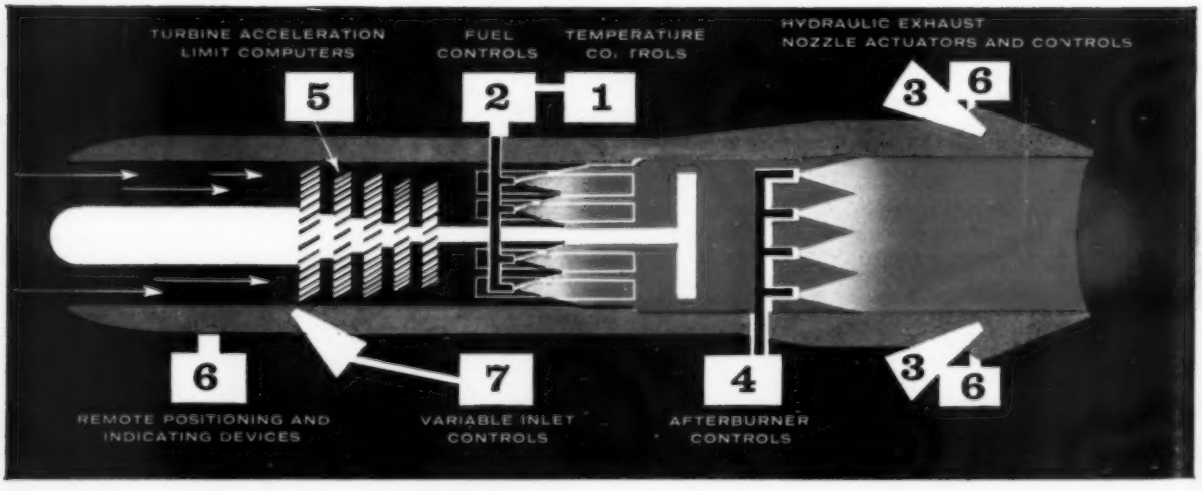

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How U.S. Tackles Problems of IRBMs, ICBMs

By ERIK BERGAUST

Eger V. Murphree's billion dollar responsibility embraces some new and sophisticated missile development concepts. The enormous task that he faced at the time he took on the missile czar job has become even more enormous—not money-wise, but in scope.

Both IRBM and ICBM development has progressed more rapidly than at first anticipated. As a matter of fact, the ICBM programs already have reached the stage where selection of launching sites is being discussed.

Planning for ICBM launching sites is now under way. This is one of the new missile system concepts Murphree and the Defense Department must tackle successfully.

Overseas Launching Sites?

At a news conference in Rome recently, Secretary of the Air Force, Donald A. Quarles, confirmed that work will be pushed to completion on four main air bases in Spain. One of these bases was called a "double base" that might be counted as two. Originally the Air Force counted on nine bases in Spain, but Quarles said it was not certain that all of these would be completed. There has been some talk about the possibility of using overseas bases for launching sites for both IRBMs and ICBMs, but—as can be expected—no official statement has been issued in that respect.

It is not known whether Quarles discussed the missile launching site problem with Spanish authorities during his recent trip. But it is quite probable that he did.

Quarles did say that "there is no question that we will complete those Spanish bases we have started and on which we place great value."

• **Other U.S. overseas bases** feasible for long-range missile operation include those in Morocco. The original agreement for these bases was made with the French Government, which acted on behalf of Morocco. Since Morocco now has its own government, negotiations will be carried out with both the French and the Moroccan authorities for continuation of the American bases.

In all probability, the American bases in Saudi Arabia and Iceland will not be considered for long-range or intermediate-range missile launching. Saudi Arabian King Ibn Saud has granted the United States only temporary permission to continue USAF operations in that country. Although the United States Government intends to negotiate with the Saudi Arabian Government for the purpose of obtaining permission to stay on, it is not likely that IRBM or ICBM launching site negotiations will be attempted. The same applies to Iceland, where the United States' position is rather weak.

Underwater Launching

It is anticipated that at least some of our ICBM launching sites will be constructed at isolated Pacific islands. One may be built near Japan. Another site may be built in Alaska.

Construction technique to be employed has not yet been decided upon, and although the Defense Department is studying this aspect of IRBM and ICBM weapons systems, it is understood that no construction contracts have been awarded.

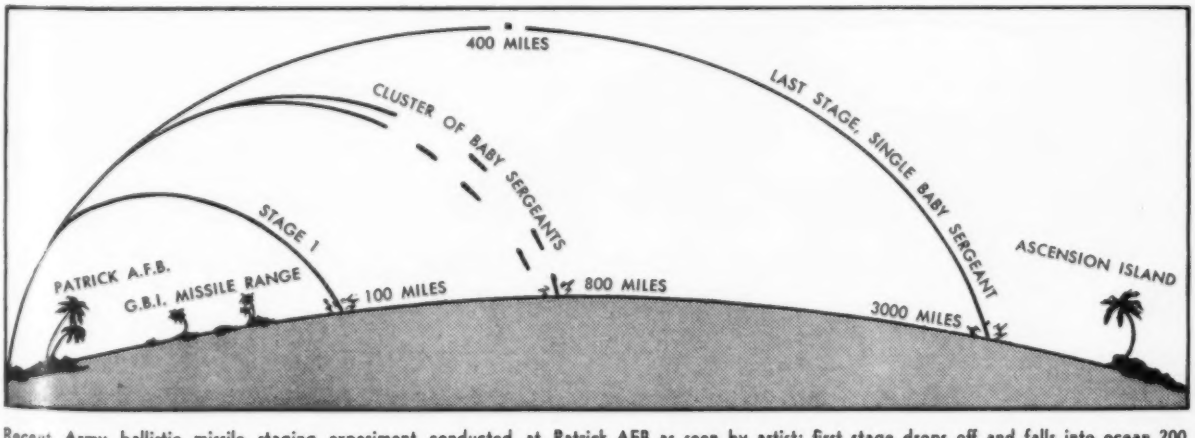
In case of an enemy attack our ICBMs must be ready for launching in a matter of minutes. Launching must be simple and foolproof. The missiles will have to be stored and fueled in such a manner that the necessary service for launching will require only a few quick routine operations. Consequently, the missiles will more or less have to be stored in upright launching positions.

Since the nuclear warheads involve great hazards, the launching sites must be invulnerable to enemy attack. These considerations, then, point to the feasibility of building the launching sites underground or even underwater.

Logistics, installations and operations for an ICBM launching site problems are tremendous in scope. In this sense, the V-2, which was quite complex was simple to launch in comparison with an ICBM. These factors, furthermore, indicate that it is difficult to operate an ICBM launching site in secrecy.

As a matter of fact, magnitude of the underground/underwater construction requires such vast forces of labor and construction equipment that it will be almost impossible to build the sites in complete secrecy.

Of course, every ICBM or IRBM launching site must have the best of logistic support at all times. It may be found, for this reason, that every site will have to be operated in conjunction with, or at least very near, a regular air base. Large seaplanes may



Recent Army ballistic missile staging experiment conducted at Patrick AFB as seen by artist: first stage drops off and falls into ocean 200 miles out, cluster of second-stage units reach 800 miles. Last stage zooms to 400 miles altitude and covers 3,000 miles. A new record.

be used successfully for such support once the site has been built and is operational.

• **Defense against** an ICBM attack is extremely difficult. We are currently working on anti-missile missiles or attack missiles. In all probability our missile designers will come up with a missile that can knock another missile—even an ICBM—out of the sky. But—and this is the most important factor—can we develop the completely automatic system that is needed to detect every enemy ICBM far enough in advance, so that the anti-missile missile can be launched in time?

Inadequacy in our radar warning systems in the arctic regions indicates that only a small percentage of an enemy's ICBMs will be detected and shot down with our current radar spotting and tracking devices. The best defense against an ICBM or IRBM attack probably lies in the destruction of the enemy's launching sites—another reason why such sites must be highly secret. Obviously, the job that lies ahead for the Defense Department, to complete a dozen or more ICBM and another dozen IRBM launching sites within the next two or three years, is practically as important as the building of the missiles themselves.

A conservative estimate is that the first operational ICBMs will be ready in 1959. This is at least one year earlier than anticipated at the time when the Defense Department awarded the prime contracts. The advancement is a direct result of the gain in missile technology during recent years.

Of the five major missile development categories—framework, powerplants, guidance, nose cone and warhead—it is generally accepted that the contractors developing the powerplants and the nose cones are on or ahead of schedule. Furthermore, most experts seem to think that a suitable thermonuclear warhead will be developed in time. Greatest difficulties are anticipated for the developers of the guidance systems.

It is apparent that an ICBM must be extremely accurate. Actually, guidance engineers confirm that it is not any more difficult to guide a vehicle to the moon or Mars than it is to develop successfully a guidance system such as the ones to be employed in our ICBMs. It is, incidentally, quite interesting to note that various phases of the ICBM testing might be done in terms of space flight. Thus, some of the early ICBMs might be launched into space for some scientific research purpose.

• **Cameras and telemetering equipment** will be mounted in the nose cone. An attempt might even be made to bring the vehicle into an orbit that takes it around the moon and back to earth. Guidance engineers could not have any better opportunity to test their control systems; if they can send a missile around the moon and back to earth, they can also send a missile to Moscow.

Equipment reliability is a most important factor in missile development. For years it has been seemingly impossible to perfect various guidance systerms beyond jamming and malfunctioning. However, the last 12 months have been highlighted by better and more reliable guidance systems, and there is no doubt that adequate systems will be built for our ICBMs.

Nevertheless, the question is whether these systems will be ready at the time the missile itself is. It is also quite possible that several of the circumlunar and other flight operations in the "not-so-outer" space will be attempted as part of guidance system evaluation and that improvements can be made only after observations have been made as to what happens during such flights.

State of the art—as far as ICBMs are concerned—seems quite satisfactory.

The trouble with our ICBM programs, if any, was that the Government was much too slow in getting them under way.

Tight Schedule for IRBMs

For some reason the Defense Department wants—and expects to get—the intermediate-range ballistic missiles before the long-range weapons. It seems the government planners think it is easier to build a not-so-long range weapon—although the strategic requirements are the same as for ICBMs, i.e. atomic or thermonuclear warhead and pin-point accuracy.

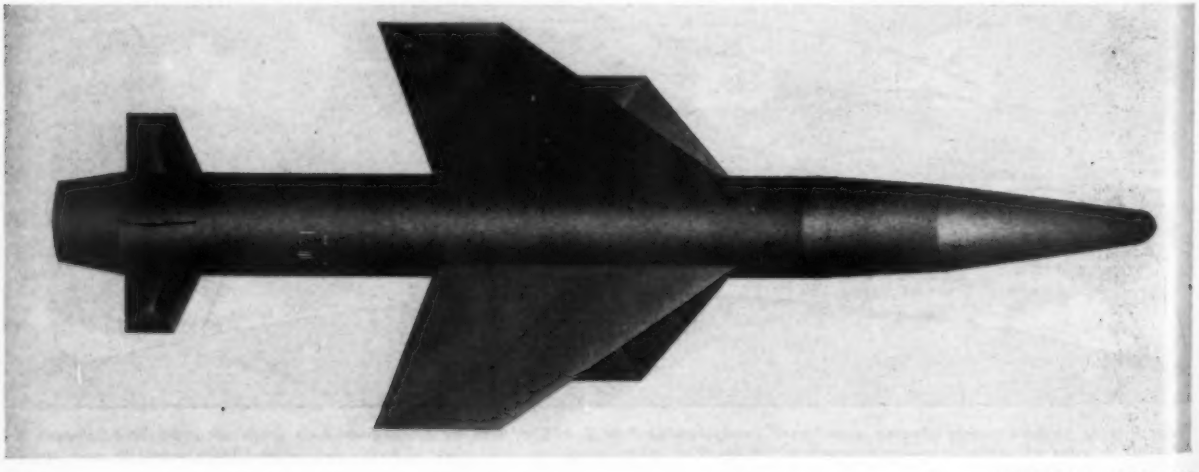
Indication that our IRBM development is progressing ahead of schedule was given a few weeks ago, when Redstone engineers launched a ballistic step-vehicle some 3,000 miles, reaching an altitude of approximately 400 miles.

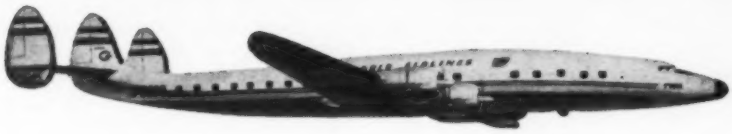
The experiment, which took place at Cape Canaveral, was conducted as part of the Army's Jupiter program. A Redstone rocket, with a cluster of Baby Sergeant missiles on top of it, hurtled a third-stage Baby Sergeant out over the GBI range. The distance achieved is the greatest known so far for any rocket vehicle. Purpose of the test—believed to be one in a series—was to explore techniques for separation of stages.

The IRBM people developing the Jupiter and the Thor weapons systems, as well as the Navy FBM (fleet ballistic missile), are under terrific pressure from the Defense Department. Schedules are extremely tight. At the same time, the fact that all three services are engaged in IRBM develop-

Artist's Version of Lacrosse Close-Support Missile

Army's Lacrosse close-support battlefield missile as drawn by AMERICAN AVIATION'S artist. Lacrosse is powered by a Thiokol solid rocket, was developed by Cornell Aeronautical Laboratory and will be produced by the Martin Co., Baltimore.





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ment does not make the situation easier. When one adds to that the fact that Navy also wants to try out solid-propellant IRBMs, it is easy to understand why numerous difficulties are encountered.

The Navy's decision to look into high-energy solid propellants has been praised by many authoritative experts, since simplicity in handling is a must for naval missile operations. The continued extensive research in our propellant laboratories is beginning to pay off, and high-energy solid propellants (as well as many new liquid combinations) are known to be in existence. If successfully developed, the Navy will get a truly great weapon in a solid propellant FBM. Such missiles could also be launched from submarines in underwater positions.

Crowded Missile Ranges

Center for the Army/Navy intermediate-range missile work is at Redstone. It is under the direction of Dr. Wernher von Braun. A recent visit to this important arsenal revealed that nothing is left untried in the effort to produce the greatest weapons of all times.

Biggest problem for Redstone scientists is that their "big stuff" cannot be flight tested at the arsenal. This means that their missiles must be taken to ARDC's Patrick Air Force Base in Florida, which has become so crowded lately that it is sometimes very difficult to squeeze in a flight test unless it has been scheduled way in advance.

Missiles from all three services are being flight tested from Cape Canaveral, and extensive expansion of the base and the range itself must be conducted if all three services are to continue their flight tests on schedule.

Crowding of the telemetering frequency bands used in missile research and development also is posing increasingly severe problems between users at launching sites and between test ranges.

Experts have reviewed the needs for better use and coordination and for improved equipment. They also have weighed the possibilities of using the newly assigned 2,000-megacycle channel to ease the crowding problem.

Stressing a need for improved automatic tracking antennas, one expert has cited a case where an antenna picked up a signal from another missile center 500 miles away and then lost track of the missile it was supposed to track. Better equipment with crystal control was needed, he said, for long-range tracking. This would also aid frequency assignment coordination.

It has been suggested that interference problems should be attacked on three fronts. These should be: (1) control of frequency usage through careful screening of all requests, (2) better control of equipment frequency stabilization to prevent waste of band space and (3) better control of radiation from closed-loop test facilities where checkouts take place inside of buildings.

Recently the Department of Defense provided a new telemetering channel in the 2,200-2,300 mc range which was expected to lessen interference problems. However, this new assignment is understood to offer little aid at this time. The new frequency seems impractical for small missiles. To produce and handle such short wavelengths, microwave "plumbing" such as waveguides are necessary.

New Missile Categories

In addition to the forthcoming giant-size job of building IRBM and ICBM launching sites, a job that will highlight the Defense Department's missile efforts during the next two years, another missile concept now has initiated a new era for this fascinating art, namely underwater missiles.

Most obvious underwater missile is the ballistic vehicle designed to be launched from the deck of a submerged submarine. This idea, conceived by the late German submarine commander Hans Steinhoff in 1943, has been developed further by the Russians and the system is known to be employed by numerous Red subs. Furthermore, solid-propellant underwater rockets used by the Red Fleet are understood to be fired directly through the torpedo tubes. These weapons are in the underwater-to-surface category, in that the missile pops out of the water, zooms into the air as a ballistic shell and falls on surface targets on land.

However, two more underwater missile concepts are in the mill—both in the Soviet and in this country—the underwater-to-underwater and the underwater-to-air missiles. In all probability, solid propellants are being considered for the latter type rocket weapon, which shoots aloft from the submerged submarine against approaching enemy aircraft.

The U.S. Navy has been slow in realizing the potentialities of this weapon system.

The underwater-to-underwater missile is actually nothing but an advanced torpedo. It differs from ordinary torpedos in that it can be used from one sub against another. No information on United States interest in this weapon system has ever been officially revealed.

The new categories of missiles now bring the total to eight:

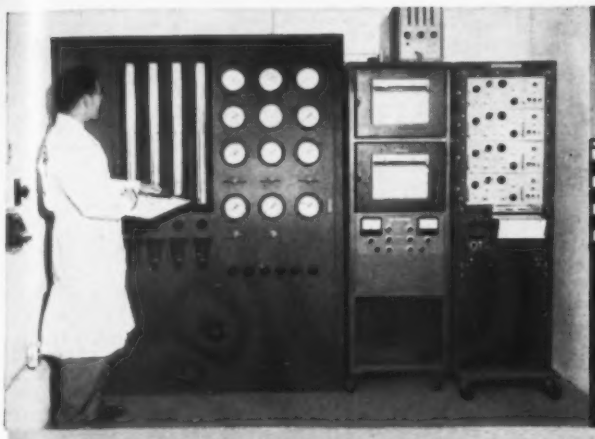
- Surface-to-surface (SSM).
- Surface-to-air (SAM).
- Air-to-surface (ASM).
- Air-to-air (AUM).
- Air-to-underwater (AUM).
- Underwater-to-air (UAM).
- Underwater-to-surface (USM).
- Underwater-to-underwater (UUM).

Numerous missiles are being developed as test vehicles for other missiles and weapons systems, and numerous missiles are also being built for scientific research only.

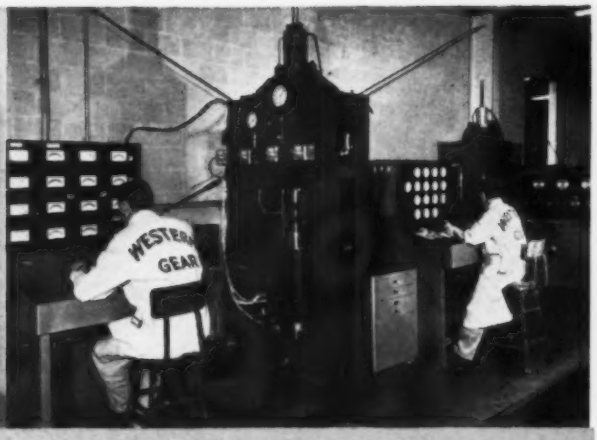
Some experts have hinted that each individual ICBM will cost between $4,000,000 and $5,000,000. Of the current $1.2 billion earmarked for missiles, a great portion will go for ICBM development, and even more money—probably as much as $2 billion—will be spent on missiles during the next fiscal year.

More than 20 per cent of the money allocated for aircraft and major procurement during the current fiscal year is being spent on missiles and related equipment.

Army missile activities are in the spotlight these days. Redstone Arsenal commanding general, Maj. Gen. H. N. Toftoy poses in front of Army's fully operational guided weapons: Nike, Honest John and Corporal.



Instrumentation for guided missile test cell



Production testing linear actuators

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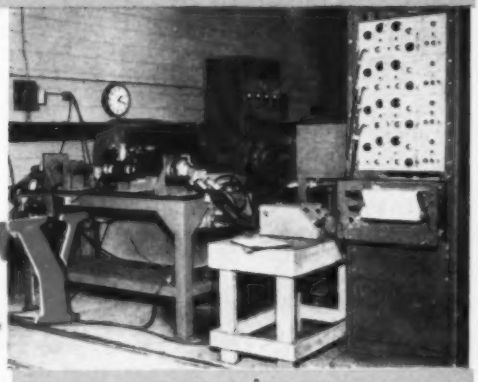

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U.S. Missile Arsenal

Manufacturer	Designation	Powerplant	Remarks
SURFACE-TO-SURFACE			
Chance-Vought	*Regulus* SSM-N-8 *Regulus II*	1 Allison J33-A-18A jet plus two Aerojet-General solid rockets. Prototypes powered by Wright J65; Production models get GE J79.	In service. Command guidance. Supersonic
Chrysler	*Redstone*	North American liquid rocket	Operational soon
Chrysler	*Jupiter*	North American liquid rocket + booster	IRBM, derived from *Redstone*
Convair	*Atlas* SM-65	North American liquid rocket	ICBM, thermonuclear warhead
Douglas/Emerson	*Honest John*	Hercules solid rocket	In service; unguided artillery rocket
Redstone Arsenal	*Little John*	Hercules solid rocket	Derived from *Honest John*
Douglas	*Thor* WS-315A		IRBM under development
Firestone	*Corporal E* SSM-A-17	Liquid rocket (Jet Propulsion Laboratory)	Gilfillan beam guidance; also Corporal F; in service
Martin	*Matador* TM-61A/B	Allison J33-A-17 + solid boosters (later versions to have more powerful J33)	Guided bomber; also TM-61B (longer), TM-61C and TM-61D. In service
Martin	*Titan* WS-107	Aerojet liquid rocket	ICBM under development
North American	*Navaho* SM-64	2 Wright ramjets + North American liquid rocket as booster	Under development in several versions
Northrop	*Snark* SM-62	P & W J57 jet + 2 boosters of 33,000 lbs. each	In production
Cornell Lab/ Martin	*Lacrosse*	Thiokol solid rocket	Close support battlefield missile
SURFACE-TO-AIR			
Bell	*Shrike* SAM	Liquid rocket	
Bendix/ McDonnell	*Talos* SAM-N-6	McDonnell ramjet + booster	In production; also *Talos-L* and *Talos-W*
Bendix	*Loki*	Solid rocket	In production
Boeing	*Bomarc* IM-99	2 Marquardt ramjets + Aerojet-General solid rocket	Missile carrier (*Falcons*)
Convair/Bendix	*Terrier* SAM-N-7	Aerojet liquid rocket + solid rocket	In service. Beam guidance. Also *Terrier 1* and *Terrier 2*
Convair	*Tartar*	Solid rocket	In production
Douglas/Western Electric	*Nike* SAM-N-7 *Nike B*	Aerojet liquid rocket + solid rocket booster	In service, *Nike* B is a slightly larger, longer range
Raytheon	*Hawk* SAM	Liquid rocket	In production
AIR-TO-UNDERWATER			
Fairchild	*Petrel* AUM-N-2	Fairchild J44 jet	Anti-submarine missile; launched from aircraft
AIR-TO-SURFACE			
Bell	*Rascal* GAM-63	Liquid rocket	Launched from B-52 or B-58
Chance-Vought/ Eastman Kodak	*Dove* ASM-N-4 and-5		In production
Martin	*Bullpup* ASM-N-7	Aerojet-General solid rocket	Under development
AIR-TO-AIR			
Douglas	*Ding-Dong*	North American liquid rocket	Under development, atomic warhead
Douglas/Sperry/ Raytheon	*Sparrow* AAM-N-2	Aerojet solid rocket	In production and in service; also AAM-N-3 and N-4
Hughes/Philco	*Falcon* GAR-98	Thiokol solid rocket	In production. Also *Falcon 2* and *Falcon 3*
Philco/Martin	*Sidewinder* AAM-N-7	Solid rocket	Operational; infra-red homing
Fairchild	*Goose*	Fairchild J83 or GE J85	ECM vehicle, no warhead
ANTI-TANK			
Aerophysics Development	*Dart*	Solid rocket	Built for U.S. Army; wire guidance, soon operational

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Best New Products and Processes of 1956

No single segment of the aviation industry is harder pressed to meet the demands of higher speed, higher flying aircraft and missiles than the aircraft equipment producer.

In virtually every new specification, aircraft and missile accessories must answer the challenge of increased versatility of operation, within ever-decreasing space envelopes and more restrictive weight allowances.

And they must do the job with the same, if not greater reliability.

Some examples:

• Air conditioning systems capable of producing turbine discharge temperatures as low as minus 75°F—yet weigh only two-thirds that of their predecessors having the same performance.

• Aircraft and missile generators of the environment free type, rated to produce powers up to 30 kva regardless of speed, temperatures and altitudes.

What has industry been doing to meet these challenges? In the following pages, AMERICAN AVIATION presents the results of a survey of equipment manufacturers as to what they consider their top aviation contribution.

New Doppler navigation systems . . . miniature gyros for inertial guidance systems . . . jet starters . . . these are but a few of the products reported, some for the first time. But even more significant, they are the developments which their producers rank at the top of the list in their engineering battle to meet the demands of higher speed, higher altitude flight.

AIRCRAFT & ENGINE ACCESSORIES

Highlight of activity at Hamilton Standard Division, United Aircraft Corp. this year has been the start of production of three new aircraft and engine accessory items—jet fuel controls, starters for turbine engines, and air-conditioning systems.

The latter has been developed for one of the world's fastest fighters and is the lightest, most compact and versatile package yet designed, H-S says. It occupies a rectangular space of about 40″ long, 16″ high and 8″ wide and weighs 45 lbs. dry.

The new system delivers refrigerated or heated air to condition and pressurize the crew compartment and electronic equipment. It also supplies de-fogging air for the windshield. A water separator includes a temperature control to limit discharge temperatures to about 35°F minimum at altitudes below 25,000 ft.

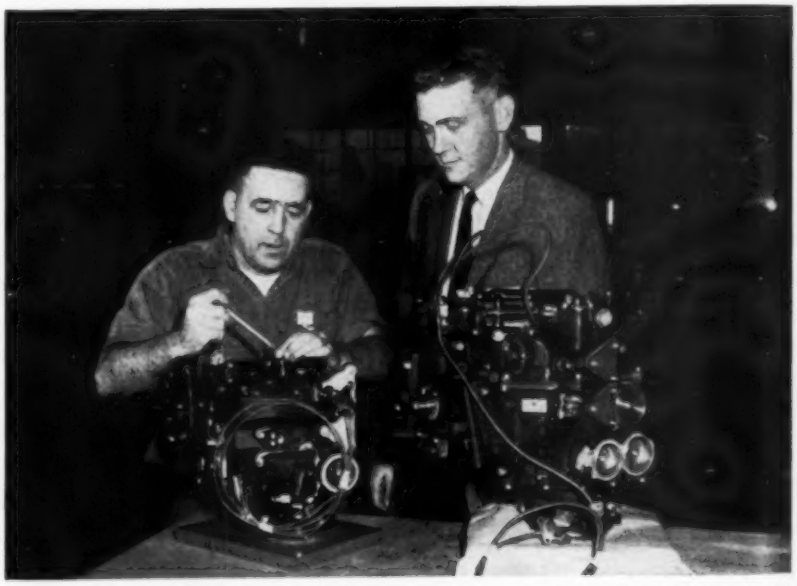
The cooling turbine, turning at 100,000 rpm, delivers about 35 lbs. of air per minute. Among other features are a stainless steel air-to-air heat exchanger of new, lighter design an air-to-water heat exchanger to provide a heat sink lower than ram air temperature, an electronic temperature control and a defogging air control system.

System produces turbine discharge temperatures as low as —75°F. Compact design and installation in a complete package eliminate considerable ducting in one production application already in service.

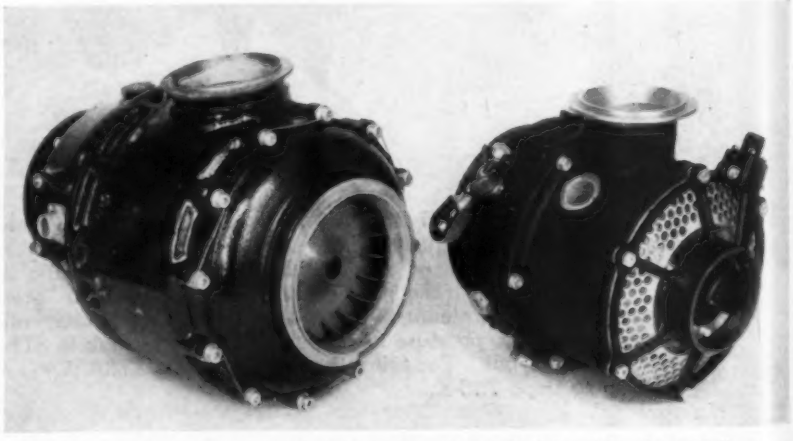
Before development of this packaged concept, H-S says, a unit having equivalent functions would weigh about 50% more and occupy considerably more critically-needed aircraft space.

Fuel Controls

H-S activity in fuel control engineering has stressed establishment of definite weight limitations for these units and a system of rigid check points



New and old series of Hamilton Standard jet engine fuel controls. New unit (left) is designed for engines of twice the thrust, yet weighs half as much as older types.



Old and new jet engine pneumatic starters. New starter (right) weighs about 15 lbs., uses 176 cu. in. of space, delivers same peak output of former types (left).

throughout the design period toward one end—development of a new line of lightweight controls. The new series are designed for engines of twice the thrust and size of those for which H-S has been producing over the past five years, yet weigh only half as much.

Weight reductions in their design were realized through use of new kinds of servo mechanisms, attention to execution of schematics to reduce complexity and the thorough investigation of new metals and materials. Despite final reductions in size and weight, fuel control stability, speed of response and accuracy were retained at the same rigid level of earlier types.

Jet Starters

Hamilton Standard's newest pneumatic starter, which weighs about 15 lbs. compared to 30 lbs. for its predecessors, occupies a space envelope of 176 cu. in. compared to 332 cu. in. formerly. It delivers the same peak output of 90 hp.

These weight and size reductions were made possible by a redesign of the starter's gear train to eliminate some gears and make those remaining lighter. Use of a sprag-type clutch instead of jaw-type, and a major revision of gear train schematics, resulting in greater compactness, contributed importantly to the successful development, company engineers say.

In more than 1,600 cycles of successful operation, Hamilton Standard reports the new unit passed its qualification test program at a level far higher than expected.

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HYDRAULICS ACCESSORIES

Vickers, Inc. has extended its development program in aircraft and missiles hydraulics in 1956 with the addition of new accessories ranging from miniature pumps for missiles to "packaged" hydraulic hoists for helicopters.

New components include a hydraulic-powered aircraft and missile electrical power package; lightweight, hydraulically-pressurized reservoirs, constant gain solenoid selector valves.

Smallest of its miniature pumps is the Model 3906, weighing less than one pound and measuring 2½" long and 1⅜" in diameter. It is rated at 4.4 hp and 2.5 gals./per/min. flow when turning 12,000 rpm in a 3,000 psi system.

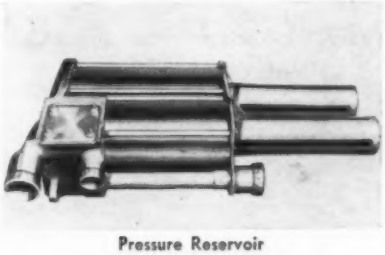
• **Vickers'** hydraulic-powered electrical power packages are designed for use in place of a conventional inverter either for new systems or to "beef up" the output of existing systems that are loaded to capacity.

Initially, these systems were developed for an output range of 0.5 to 3.0 kva with corresponding weights varying from seven to 19 pounds. However, a larger unit of 10 kva output weighing 40 lbs. has been adopted for a specific missile installation.

Extended use of today's hydraulic fluids at higher temperatures is now possible in an "airless" system produced by Vickers hydraulically-pressurized reservoir. Reason is that the absence of air in the reservoir eliminates the fluid breakdown and sludging associated with oxidation at elevated temperatures.

One reservoir model incorporates a 40-micron filter and provides a 140-cu.-in. capacity at a weight of 12 lbs. Unit is contoured to fit engine curvature and measures 4" x 11" x 18".

The Vickers personnel rescue hoist system is a packaged, hydraulic-powered unit having a basic 600-lb. capacity. It



Pressure Reservoir

is designed for installation in an aircraft or helicopter in less than an hour, can be removed just as quickly when no longer needed or for maintenance.

• **Packaged design** is also a feature of new constant gain solenoid selector valves that include seven-units-in-one to achieve minimum weight and reduced external plumbing. They are basically a four-way, closed-center, solenoid selector valve with special modifications to suit them for a hydraulic system using an on-off type servo-mechanism control.

They are designed specifically for high pressure, high temperature use where conditions call for two-way actuation of controls at two different rates of response, such as in jet engine variable exhaust nozzle controls.

The Vickers valves are proposed for operating pressures up to 4,500 psi, air temperatures up to 350°F, system fluid temperatures up to 300°F and return fluid readings up to 400°F.

Packaged Hoist

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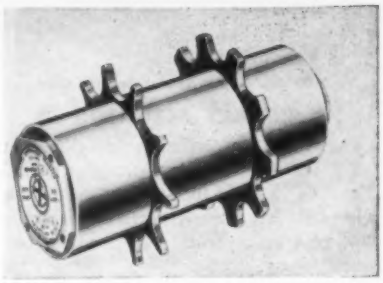
AMMUNITION BOOSTER



American Bosch Division, American Bosch Arma Corp. selects as its leading aviation development a new electric ammunition booster that will move 1,400 round of ammunition per minute at a 50-lb. belt load and operate for 84,000 rounds without need for servicing.

The Type ABA booster consists of a small high-speed electric motor and three stages of planetary gears with a total ratio of more than 100 to 1. It operates on 3-phase, 400-cycle, 200-volt current at temperatures from —100° to 150°F.

Basic function of the Type ABA is to support a belt of standard caliber .50 machine gun ammunition on its sprockets and move the ammunition toward the gun automatically as it is fired.

Circle No. 24 on Reader Service Card.

AFTERBURNER FUEL CONTROLS

Top development at **Chandler-Evans Division,** Pratt & Whitney Co. in recent months is an improved version of its Model AR-6 afterburner fuel control that weighs 15 lbs. and handles flows up to 35,000 lbs. per hour.

Previous models weighed 16 lbs. and were rated up to 25,000 lbs. per hour. To date, Chandler-Evans has built some 4,500 AR-6 assemblies for use in such aircraft as the North American F-100 and F-107, McDonnell F-101, Convair F-102, Douglas F4D, Chance Vought F8U and Republic F-105.

Basic design of the unit is that of a by-pass regulator operating on a constant metering head across an orifice whose size is regulated directly by airflow acting on a bellows. Initially the control had a spring-operated shut-off

valve, changed in later series to a servo (by-pass) valve.

Overall dimensions of the AR-6 are 9″ x 7″ x 6″.

Circle No. 15 on Reader Service Card.

ROTARY ACTUATOR

Newest in aviation developments at **Barber-Colman Co.** Aircraft Controls Div. is a 0.56-lb. rotary electro-mechanical actuator designed for duty as an emergency fuel valve in aircraft fuel systems.

The Type PYLC actuator is said to move a 7.5-lb./in. load 95° in two-tenths of a second and to operate in ambient temperatures ranging from —65° to 300°F.

Travel limit switches are integral and adjustable for strokes from 0 to 360 degrees. Output shaft is 3/16″ diameter and serrated. Driving power is supplied by a permanent-magnet motor and shorting of the motor armature leads through external switching serves as a dynamic brake.

Overall dimensions from face of mounting pilot to end of motor is 4 5/32″.

Circle No. 56 on Reader Service Card.

HIGH ALTITUDE SPARK PLUG

Entry by **AC Spark Plug Division** of General Motors as top aviation development is its new HSR-83P spark plug, a high-altitude, all-weather shielded type incorporating a resistor and platinum electrodes.

Of ¾″—20 construction, the HSR-83P plug includes an all-weather connector with grommet seats on the insulator.

This, according to AC, forms an electrical, moisture-proof and altitude seal and eliminates barrel flashover.

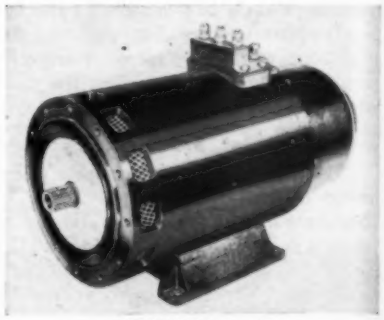
In manufacture, the shielding barrel and shell are assembled, lock-crimped and bonded to form a one-piece, leak-proof assembly. Shell threads and gasket seat are machined to a close finish to aid heat transfer, and shell and barrel surfaces are coated to inhibit corrosion.

Equally important, says AC, is the role of platinum electrodes in extending plug life and increasing performance under severe operating conditions. Platinum is highly resistant to corrosive and erosive effects of combustion, is ductile, has a much higher melting point than copper or nickel, and requires only a small cross section for plug use.

Circle No. 10 on Reader Service Card.

AIRCRAFT GENERATORS

Jack & Heintz, Inc. this year has introduced no less than five new aircraft and missile generators, four intended for military aircraft and missiles and a 450-amp. model for commercial installations.



160 KVA Generator

They include thermal lag, vapor-cooled and oil-cooled designs and a 160 kva model plus the commercial type. Specifications on the individual types are as follows:

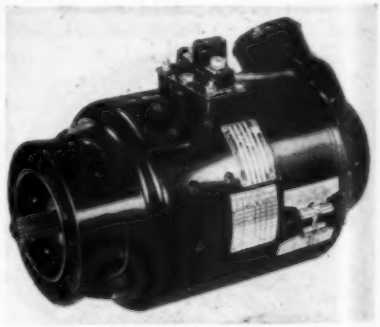
Thermal Lag Generator

Model—31186-001	Power factor—0.9 min.
Rating—10 kva	Weight—32 lbs.
Volts—120/208	Length—10 in.
Phase—3	Diameter—7 in.
Frequency—400 cps	RPM—12,000

Model 31186 is tabbed as an "environment-free" generator for short-duration missile flights. It is designed to produce full rated power throughout flight without cooling.

Vapor-cooled Generator

Model—G188-5	Power factor—0.8 min.
Rating—30 kva	Weight—66 lbs.
Volts—120	Length—10 in.
Phase—3	Diameter—7 in.
Frequency—400 cps	RPM—12,000



450 Amp. Generator

The J&H 160-kva generator, said to be the highest-rated unit ever designed for aircraft, weighs 260 lbs. and measures 22″ long by 11″ diameter. Developed for Navy Bureau of Aeronautics primarily for nuclear-powered aircraft, it is also being considered for current multi-engine types.

Circle No. 128 on Reader Service Card.

Eastern Airlines standardizes on the HOBART 871 for better performance . . . greater savings

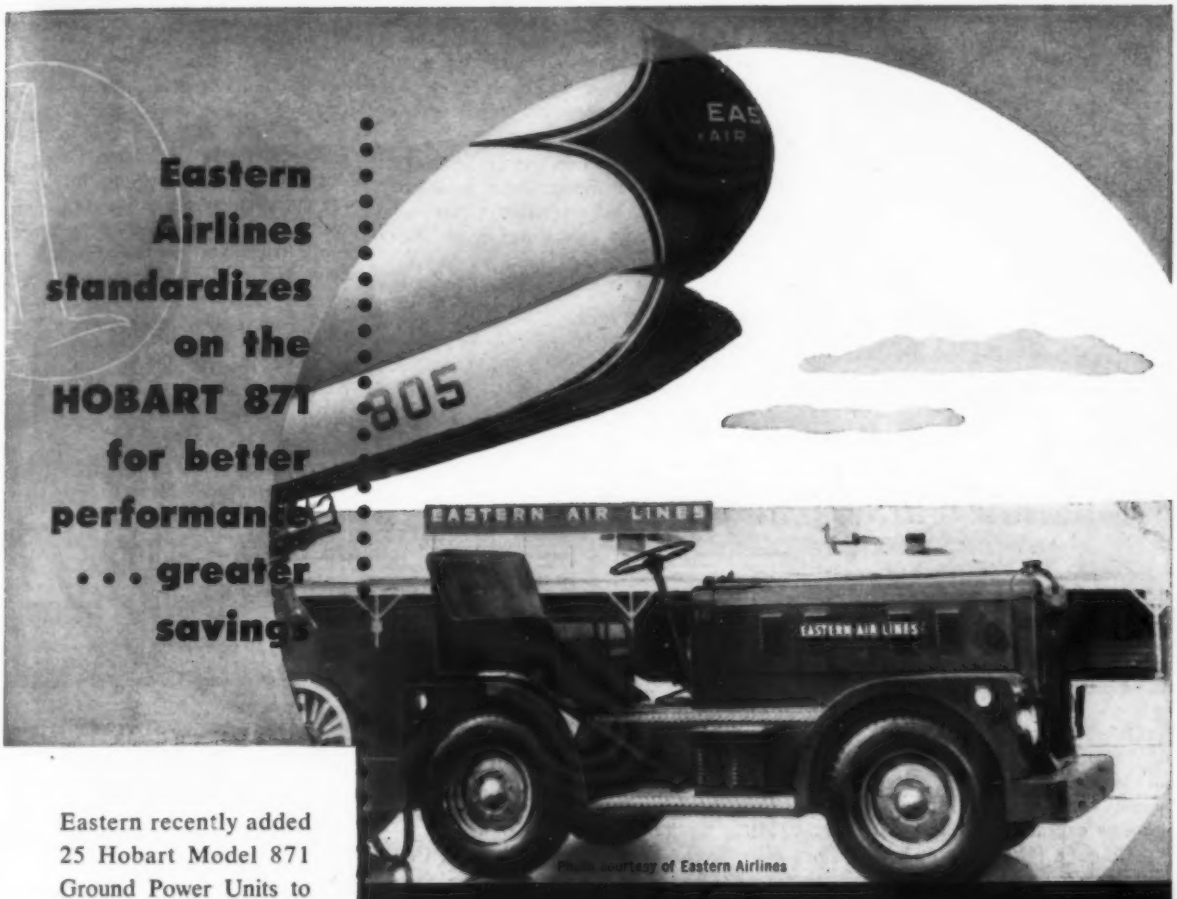


Photo courtesy of Eastern Airlines

Eastern recently added 25 Hobart Model 871 Ground Power Units to its fleet. They have standardized on the 871 Self-Propelled Unit because it has versatility to handle any aircraft they are flying to date, yet its simplicity of operation enables them to get the usage results they must have. They know it is dependable and always available where they need it—when they need it. It includes every wanted feature. Eastern chose the 871 *because only the best* is good enough!

The Hobart 871 is SECOND TO NONE!

The 871 is complete in every detail—there is no compromise at any point to give you the maximum you want in a ground power unit. It features automotive-type control, a comfortable seat for the operator, excellent visibility, and the Chrysler V-8 engine provides ample power to drive the generator (1000 amperes, 28.5 volts) as well as for travel up to 14 mph.

The push-button operation of the 871 maintains constant preset voltage at the output cable plug. Once the operator connects the plug to the airplane and pushes the generator load button—operation is completely automatic.

Only Hobart Gives You A DIVERSIFIED LINE

Designed especially to supply auxiliary power to airplanes while on the ground—Hobart has a large and comprehensive line of equipment to offer, not only to the air lines but manufacturers of aircraft, power plants, and components as well as research, development, and special service organizations.

You may have need in your operation for Hobart Ground Power Units. It will pay you to investigate its many advantages. Its price and ready availability are advantages, too. For full information write to the address below . . . or better still, just pick up the phone and call Troy 21223. You'll be glad you did.

HOBART MOTOR GENERATOR CORPORATION

BOX AA-106, TROY, OHIO *(Hobart Brothers Affiliate)*

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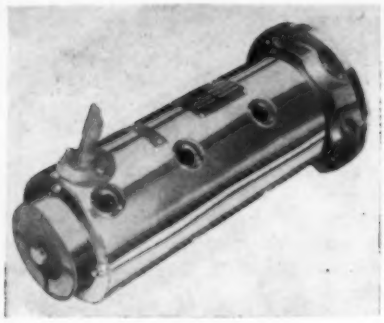

Oil-Cooled Generator

The oil-cooled Model 30051-004 for aircraft and missiles also operates independent of speed, temperature and altitude. It is rated at 2.5 kw, weighs 30 lbs. and measures 12.71 in. in length with a 4.5 in. diameter.

The G188-5 is also an "environment-free" generator but intended for long-duration missile flights. It delivers rated power regardless of speeds, ambients and altitudes.

Vapor cooling uses water from a reservoir that is injected under pressure into generator's hollow shaft. Centrifugal force propels the water over the internal surfaces of the generator, and as it picks up heat, water vaporizes, escapes as steam through an exhaust port.

Jack & Heintz commercial development, the Model G23-5, is an air-cooled d-c generator rated at 450 amps. Weight is 67 lbs. and dimensions $31\frac{31}{32}$" long by 8" diameter.

Circle No. 39 on Reader Service Card.

AIRCRAFT INSTRUMENTS & SYSTEMS

One of the top 1956 developments at **Minneapolis Honeywell Regulator Co.'s** Aeronautical Division, disclosed here for the first time, is a ½-lb. short-time or "aided" guidance gyroscope.

Called the MIG (miniature integrating gyro), it is classed by M-H engineers as the potential answer to short-term inertial needs for a low-drift-rate "floated" gyro on a mass production basis. The new unit entered production this month and low-quantity output is expected by early next year.

Although original study and design concepts originated in 1954 called for a miniaturized gyro for instrument platform stabilization, M-H success has reached the point where the MIG may be used for some missile applications. This broadened potential for the unit resulted from a new "systemized" design approach to the floated gyro field, plus several new design concepts.

M-H engineers say the new gyro has the angular momentum of the company's HIG-5 (10^5 gm-cm²/sec), with performance comparable to the larger HIGs under rugged environment. It was developed for Douglas Aircraft Co. in its Navy instrument program, but expanded for Jet Propulsion Laboratory's major missile program.

• **Big emphasis** throughout the MIG development was directed toward improving drift rate by decreasing gyro "uncertainties." Foremost of these uncertainties were dimensional stability under temperature variation and shock, lower power consumption to reduce unwanted heating, electromagnetic non-linearities and asymetries, and vibration and torques due to anisoelastic design.

The most obvious changes in final design from previous gyros are the combining of the signal and torque generators into a single dual-microsyn "Dualsyn" and the placement of the gimbal in one end of the case and the Dualsyn in the other.

The MIG Dualsyn uses four windings of .0045" wire—two ac for the signal generator and two dc for the torquer.

Other MIG design features include:

• Reduction of gimbal suspension pivot to .016".

• New method of fluid fill said to virtually eliminate balance-shifting air bubbles.

• New isoelastic spinmotor and mounting structure to improve performance under vibration.

• Improved end bellows to allow flotation fluid changes over a wide range of internal temperatures.

• **As an example** of the miniaturization realized within the MIG, M-H officials note that its internal heater element of 7 watts power is the size of a dime. Compared to the HIG's 2.75" diameter and 6" length, the MIG measures 1.75" dia. and 2.5" long.

Pilot production tests recorded by M-H show a drift of less than .5 degrees/hour. Under trim with each warmup, the random drift rate will be in the order of .15 deg./hr.

In MIG design, gimbal travel is held to within ±3 degrees of null. Operating temperature is about 180°F. Sensing element resistance is 780 ohms and spinmotor running power is 2.5 watts.

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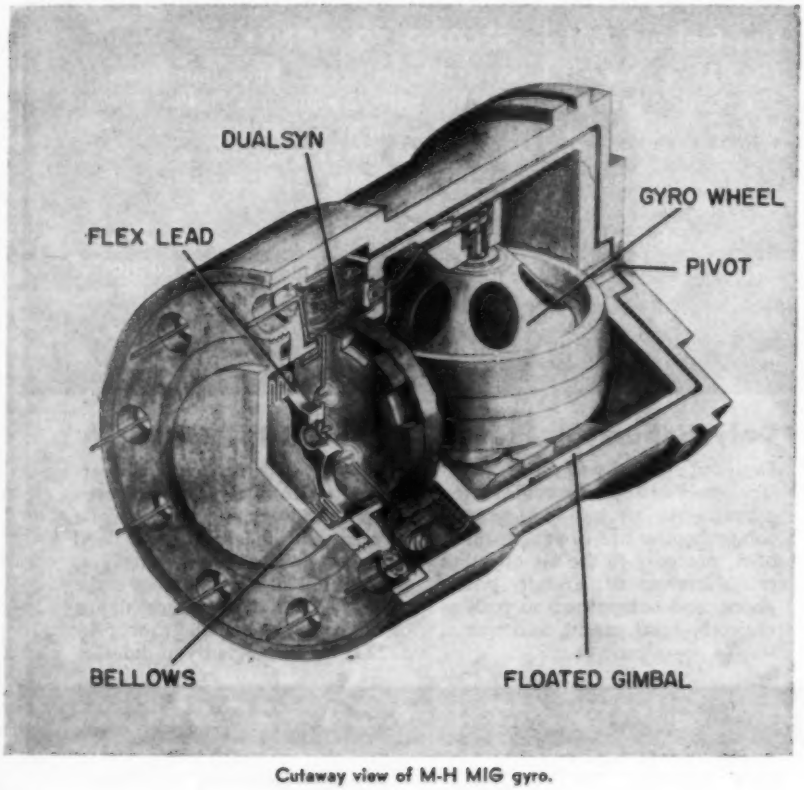

Cutaway view of M-H MIG gyro.

U. S. Air Force Photo

An Air Force cargo plane delivers vital Air Force supplies to an overseas base.

AIR MATERIEL COMMAND IS GLOBAL LINK BETWEEN RESEARCH AND COMBAT UNITS

Supplying the Air Force with the right equipment, at the right place at the right time is the mission of Air Materiel Command. Its procurement, supply and maintenance operations fill the area between research and development on one side and combat units on the other. It is the largest business in the country.

Because our Air Force is operating in all quarters of the earth, AMC is a globe-circling operation with its headquarters centered at Wright-Patterson AFB near Dayton, Ohio.

The vital logistic mission for the Air Force involves billions of dollars in procurement, thousands of airplanes, and more than a million different kinds of supply items. Organizationally, AMC includes fourteen air materiel areas, or major area depots, located in the United States, Europe, North Africa, and the Pacific. Geographically, air materiel operations extend throughout the free world.

Working with weapons systems contractors in private industry, AMC procures the equipment which has been developed and tested by the Air Research and Development Command, and distributes the equipment to combat units as needed. The never ending objective of the Air Materiel Command is to maintain an instant combat readiness, logistic-wise, in this era of super speeds and super weapons to support Air Force operations at any point on the globe. The philosophy of Air Materiel Command is that such readiness must be characterized by the closest interrelations of combat and logistic elements, by speed, flexibility, mobility and economy.

This is one of a series of ads on the technical activities of the Department of Defense.

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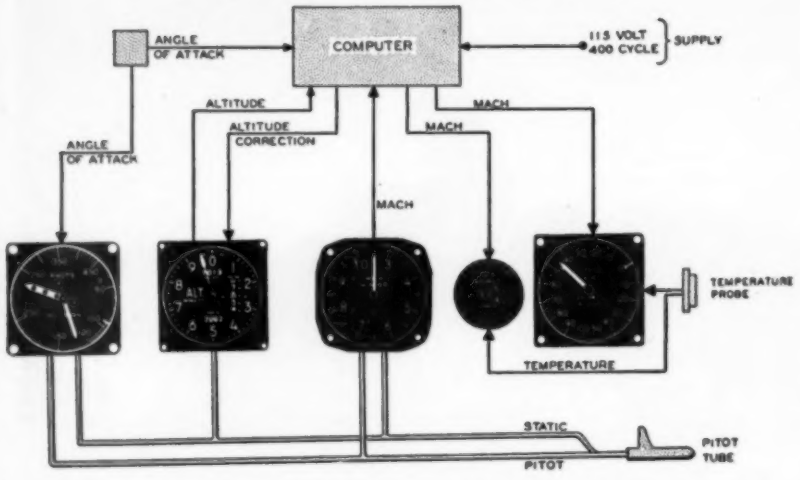
INTEGRATED INSTRUMENT SYSTEM



Top product development at **Kollsman Instrument Corp.** is its integrated flight instrument system built around an altimeter said to have a maximum error of 50 ft. at sea level and 100 ft. at 40,000 ft.

The Kollsman system, already adopted by five major airlines for use in new jet and turboprop transports, provides the pilot with corrected altitude, Mach number, and indicated and maximum allowable airspeed. It also supplies minimum safe speed for approach and landing, most efficient cruising speed, and true outside air temperature. In addition, true airspeed is given directly so that involved computations are not required.

Kollsman's IFIS depends on conventional pressure instruments that are electrically interconnected to each other and to a computer, but which can operate independently. Three basic instruments are the sensitive altimeter, airspeed indicator and a Machmeter. Other components are an angle-of-attack sensor, outside air temperature probe and a computer.

By means of servo components, the instruments are interconnected to each other and to the computer so that information signaled from one unit is used to correct data of others.

• **For example,** both Mach number and angle of attack data are fed into the altimeter to correct for inherent error in aircraft's static pressure system. Altimeter data is likewise fed into the computer where a scale error corrector supplies precise correction information back to the instrument.

Yet, in event of electrical failure, the pilot continues to receive instrument readings. Indicated and maximum allowable airspeed and Mach number are not affected, and altimeter indications revert to normal pressure accuracy.

The altimeter is of the counter type, registering thousands of feet on a drum and hundreds of feet on a pointer. Airspeed is shown over a range of 60 to 450 knots with most efficient speed indicated on a colored arc that moves around the rim of the dial face.

Kollsman Machmeter gives a continuous indication of Mach number over a range from Mach 0.3 to 1.0 and from sea level to 50,000 ft.

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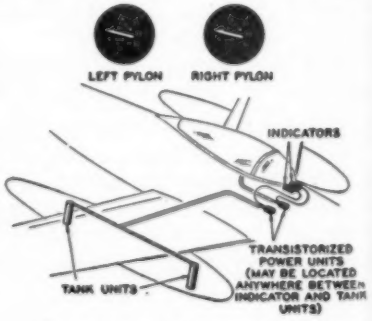
TRANSISTOR FUEL GAUGE

Leading 1956 development at **Liquidometer Corp.** is a transistorized fuel gauge designed to operate at temperatures up to 100°C in high-performance aircraft.

The Liquidometer unit uses silicon transistors and operates as an integral part of a capacitor-type measuring system. Gauge is said to be less than half the size of current vacuum tube models.



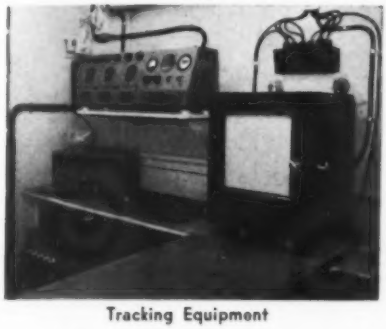
The new development is also available as part of a kit to auxiliary tank installations in existing aircraft. The kit includes a 1½-in.-diameter gauge, a silicon transistorized power unit, and the necessary number of sensing units.

The Liquidometer system operates from 115-volt, 400-cycle power. One feature on the transistorized installation is the absence of shock-mounting formerly used to extend tube life.

Circle No. 44 on Reader Service Card.

AIRCRAFT GUIDANCE

Top development this year by **Hastings-Raydist, Inc.** is an aircraft guidance system which automatically furnishes control data in both azimuth and range to an aircraft in flight.



Tracking Equipment

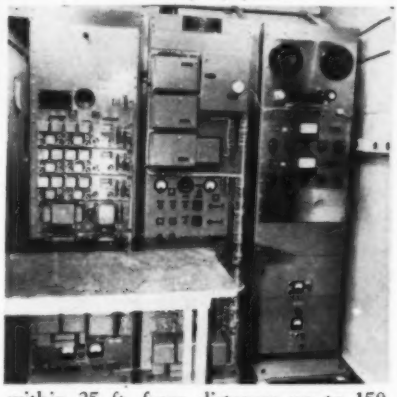
The guidance equipment consists of a basic two-dimension Raydist system using c-w phase comparison, a VHF or UHF telemetering link and a tape recorder. It supplies guidance either by preparation of a synthetic flight on a tape recorder, or by actually flying the desired flight and recording tones on the tape.

It is then only necessary, in actual guidance, to compare the recorded flight in time with the one being flown, and to give the pilot signals to modify his flight path so that it corresponds with the one recorded.

In a replay of the tape, the recorded flight is compared through a differential with the actual flight. Corrections for azimuth and range are telemetered to the pilot, using the standard airborne receiver or navigation instruments such as the crosspointer indicator.

According to company officials, the system has been used with many different aircraft types. It has successfully guided aircraft over a given point to within 25 ft. from distances up to 150 miles and altitudes up to 20,000 ft., they report.

Positioning Equipment



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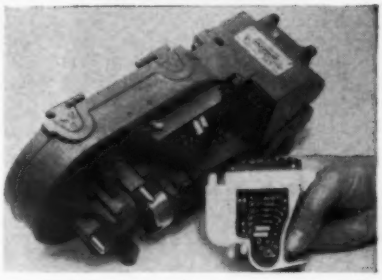
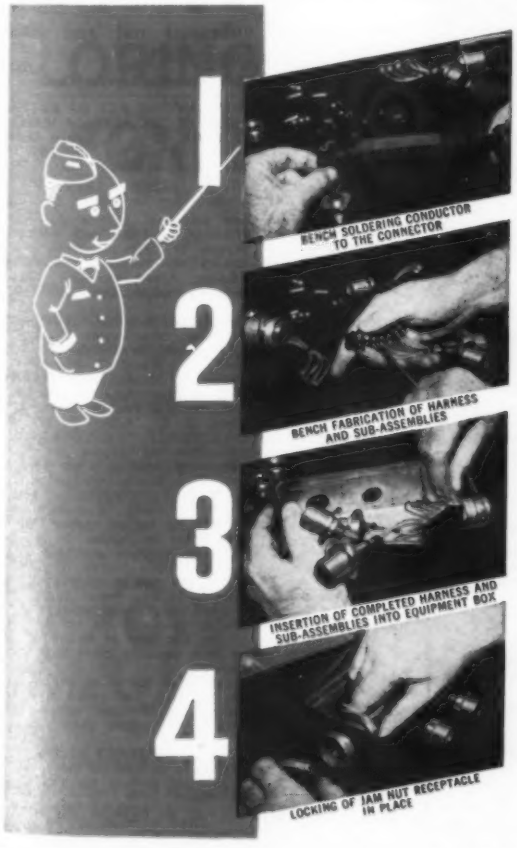
TIMING GENERATOR

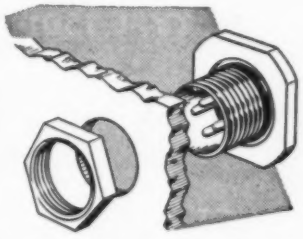


An electronic timing generator developed by **Lockheed Aircraft Co.'s** Missiles Systems Division and manufactured under license by **Electromation Co.** will be used to establish a time base on the film of airborne data-recording cameras. It can be designed to pulse at any rate from once to 3,000 times per second.

The unit, weighing 2¼ oz. and occupying 4 cu. in. of space, can be installed as an integral part of the camera, replacing bulky signal-generating equipment. Its first applications will be in GSAP cameras modified for data-recording and in the Wollensak Fastair high-speed missile camera.

The tiny generator is said to have withstood acceleration loads in excess of 100 g's. It has performed accurately at very high vibration levels, high alti-


1
BENCH SOLDERING CONDUCTOR TO THE CONNECTOR
2
BENCH FABRICATION OF HARNESS AND SUB-ASSEMBLIES
3
INSERTION OF COMPLETED HARNESS AND SUB-ASSEMBLIES INTO EQUIPMENT BOX
4
LOCKING OF JAM NUT RECEPTACLE IN PLACE



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tudes and temperatures variations within the —65°F to 185°F range.

Subminiature tubes are assembled in a sandwich with capacitors and resistors on a Fiberglas board that bears the printed circuitry. In its present application the generator has a pulsed 150-volt dc output that actuates a NE2A neon bulb.

The illumination is fed to the film by a unique light-conducting optical probe, supplied by L-W Photo Products Co. The probe makes possible exact placement of a sharply-defined timing mark wherever it is desired.

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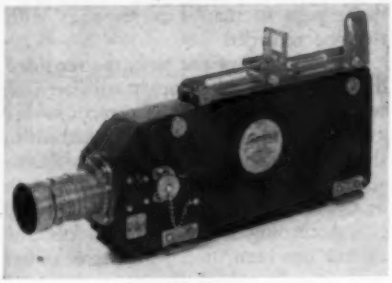
HIGH-SPEED CAMERA

Key development at **Fairchild Camera and Instrument Corp.,** Industrial Camera Div. is a new 11-pound Model HS100 airborne unit that magnifies from 2 to 280 times and photographs at from 100 to 1,000 fps.

The HS100 uses a 100-ft. spool of 16 mm film and dimensions are 11″ x 4½″ x 4″. Motor furnished with the camera 28 volts dc for the 100-1,000 frame per sec. photography speed, but other speed ranges can be achieved through use of interchangeable motors.

The HS501 is designed for 32 to 200 frames per sec. and the HS503 for 300 to 3,000 frames per sec.



HS 100 Camera

Another Fairchild development this year is its KB-5 gun camera now under evaluation by the U.S. Air Force. The KB-5 features a self-contained automatic exposure control capable of adjusting lens opening from f. 2.8 to f. 22 in 1.8 seconds.

The KB-5 carries about the same volume as the standard USAF N-9 gun camera and weighs only one pound more when fully loaded. However, by automatically adjusting its lens opening to within ½ an f-stop of correct exposure within less than a second, the KB-5 should show marked increase in usable combat photos.

Circle No. 59 on Reader Service Card.

SUBMINIATURE GYRO COMPASS

Top 1956 aviation product development at Arma Division, **American Bosch Arma Corp.,** is its new subminiature gyro reported to have an azimuth drift rate of 0.1° per hour when redesigned for aircraft applications.

The Arma gyro is of the two-degree of freedom, fluid-suspended type and measures approximately 9″ in diameter and 10½″ high. Weight for aircraft use would be 19 lbs. plus an additional 4 lbs. for a 5¾ x 3⅞-in. cnotrol panel.

In aircraft service, Arma says, the new gyro can be made compatible with speeds in excess of Mach 1. It proposes

its use as a true-north seeking compass, presuming aircraft speed information is available. However, it may also be applied as an accurate directional gyro in high-latitude polar regions at a drift rate of 0.1°/hr. or better and can accommodate unlimited roll and pitch angles, the company says.

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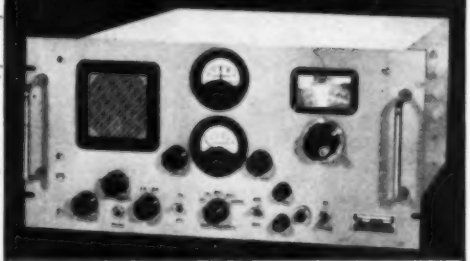
TYPE 1501 SPECIAL PURPOSE RECEIVER



This Special Purpose Receiver is an improved version of the NEMS-CLARKE 167-J1 and 167-J2. This new Receiver incorporates the best qualities of both of the former types plus many new features including a BFO. A video bandwidth control is provided to greatly improve signal-to-noise ratio when full bandwidth is not needed. It is especially useful as a high quality general purpose laboratory receiver.

SPECIFICATIONS

Type of reception	AM, FM, or CW
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Noise figure	11 db, maximum
IF rejection	Not less than 70 db
Image rejection	Not less than 40 db below 130 mc; 30 db minimum at any frequency.
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AM output	12 volts for 10 uv input modulated 30% at 1000 c.p.s. (Approx.)
Squelch	Operates on monitor circuit

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AMERICAN AVIATION, published bi-weekly at Harrisburg, Pennsylvania, for September 27, 1956.

1. The names and addresses of the publisher, editor, managing editor, and business manager are: Publisher, Wayne W. Parrish, Washington, D. C.; Editor, Wayne W. Parrish, Washington, D. C.; Managing Editor, Albert W. Bentz, Washington, D. C.; Business Manager, Leonard Eiserer, Washington, D. C.

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5. The average number of copies of each issue of this publication sold or distributed through the mails or otherwise to paid subscribers during the 12 months preceding the date shown above was: 37,598.

LEONARD EISERER,
(Signature of business manager)

Sworn to and subscribed before me this 27th day of September, 1956.

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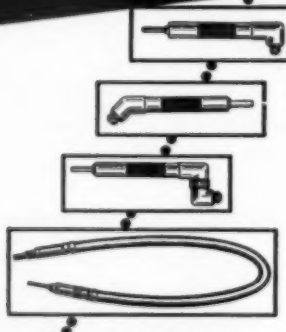

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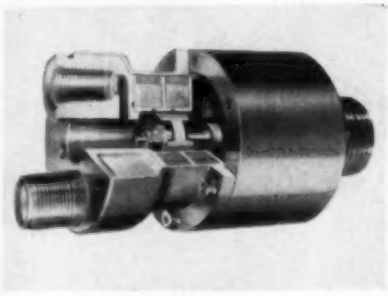
PRESSURE INDICATOR SYSTEM

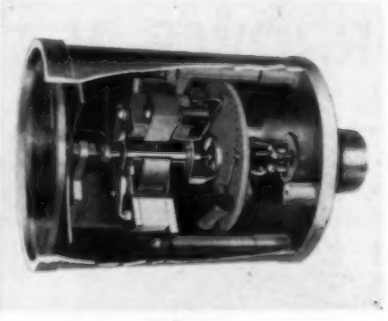
At Thomas A. Edison, Inc. Instrument Division, key aviation development in recent months is a pressure indicating system that converts pressures into electrical signals directly on an aircraft engine. Pressure data is then relayed to the pilot via bridge circuitry in the transmitter on the engine and indicator in the cockpit.



Transmitter

The system was developed in cooperation with Air Force's Wright Air Development Center and is slated for such new supersonic aircraft as the USAF's Lockheed F-104 day superiority fighter.

Big feature of the Edison development is its simplicity. Transmitters are mounted on the engine without shock or vibration isolators. Oil hose or tubing is eliminated, since the transmitter and indicator are connected by three ordinary unshielded copper wires with no intermediate transmitting or amplifying devices.



Indicator

Entire system weight is 2.5 lbs. plus wiring and power requirements are low at 1.5 watts. The transmitter has only one moving part and is frictionless. It needs no lubrication, has no delicate linkages, moving coils or bearings.

System operates from 26-volt, single-phase, 400-cycle power and has an accuracy of —2.0% full scale. Indicator has a standard 2" diameter dial, measures 2½" long and weighs 0.5 lbs. Transmitter covers a 0-100 psi range, weighs 2.0 lbs. and measures 2 3/16" diameter by 4 13/16" long.

Circle No. 8 on Reader Service Card.

FUEL FLOWMETER

Avien, Inc. this year moved into a new area of aircraft fuel measurement with a gravimetric fuel flowmeter that handles flows from 0 to 45,000 pph.

The system uses a transmitter mounted within the fuel line and a panel-mounted indicator. For multi-engine use, a separate pair of units are used for each engine plus a totalizing indicator to show total rate of fuel consumption.

Flow rate signals are obtained from the transmitter by means of two wheels within the unit. A constant-speed impeller imparts a momentum to passing fuel in proportion to the mass flow.

This momentum is imparted to a spring-restrained sensing wheel which converts it into torque proportional to mass flow, driving a low-torque potentiometer energized by dc voltage.

The output signal becomes a dc voltage directly proportional to flow and is calibrated to produce a rate indication on a servo-type indicator.

Signals for the totalizing indicator are obtained directly from the transmitter and are not affected in event of malfunction of any single engine indicator. Response time of either the system or totalizing indicator is 5 sec. for full-scale pointer travel.

For flow range existing in multi-engine installations, pressure drop across the transmitter is less than 0.5 psi and accuracy is within ± 4%. Typical power consumption including a lighting circuit is 32 watts per system.

Flowmeter Transmitter

Circle No. 54 on Reader Service Card.

COOLING DETECTOR

A "cooling effect" detector developed by **Fenwal, Inc.** is designed to sense temperature conditions in ducts leading to airborne equipment and warn when inadequate levels of cooling exist.

The Fenwal unit consists of a temperature control switch surrounded by a heating element and, in effect, senses its own overheating simultaneously with that of the unit it protects. It operates at duct air temperaure ranges from —65° to 160°F at no flow, with higher temperatures permissible if airflow exists.

The Model 18801 detector is hermetically sealed. It measures 4¾" long, $2\frac{19}{64}$" wide and $1\frac{9}{64}$" deep.

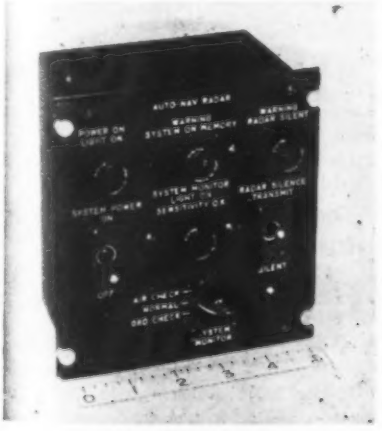
Circle No. 38 on Reader Service Card.

DOPPLER NAVIGATION SYSTEM

General Precision Laboratory, Inc. rates its development of the AN/APN-66 Doppler navigation system as its key contribution to aviation in 1956.

It employs the Doppler effect to directly measure ground speed and drift angle automatically, anywhere in the world. It is a self-contained navigation system requiring no outside aids such as ground-based stations or celestial fixes.

GPL developed the system for



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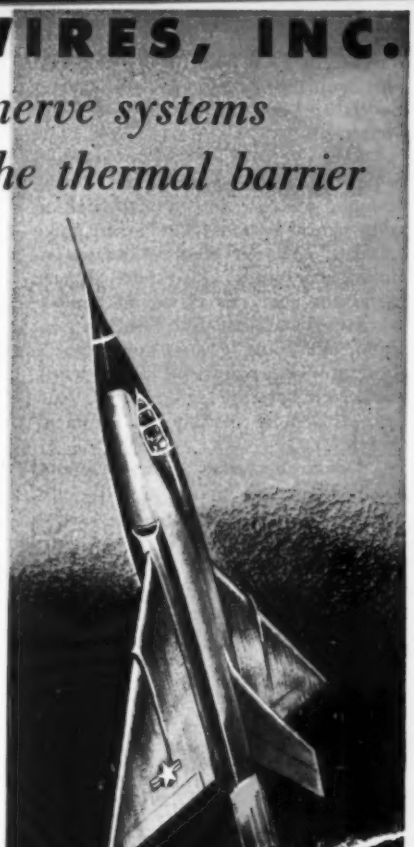

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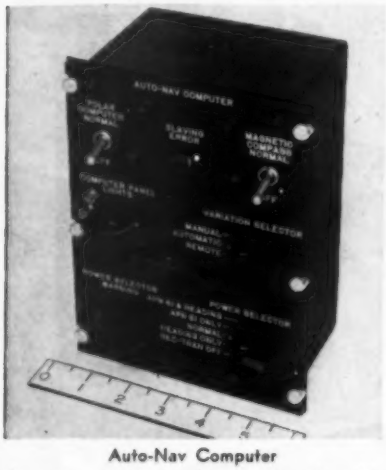
Wright Air Development Center's weapons guidance laboratory. Production models are now in use in Air Force aircraft.

APL rates the AN/APN-66 system as a significant technological breakthrough, since the delay in computation using optical or radar fixes often make the data obtained obsolete because of the higher speeds of modern aircraft. Its advance over all classes of present-day navaid such as VOR/DME, Tacan, Loran, etc. using ground-based aids is apparent, GPL points out, as they lack world-wide coverage and present a wartime problem in possibly aiding enemy aircraft.

• **Basic operation** of the Doppler system hinges on transmission of electromagnetic pulses from the moving aircraft to the ground. Because of Doppler effect, the return pulses will be slightly shifted in frequency. By measuring this shift of pulses, the AN/APN-66 determines aircraft ground speed and drift angle due to winds. And this



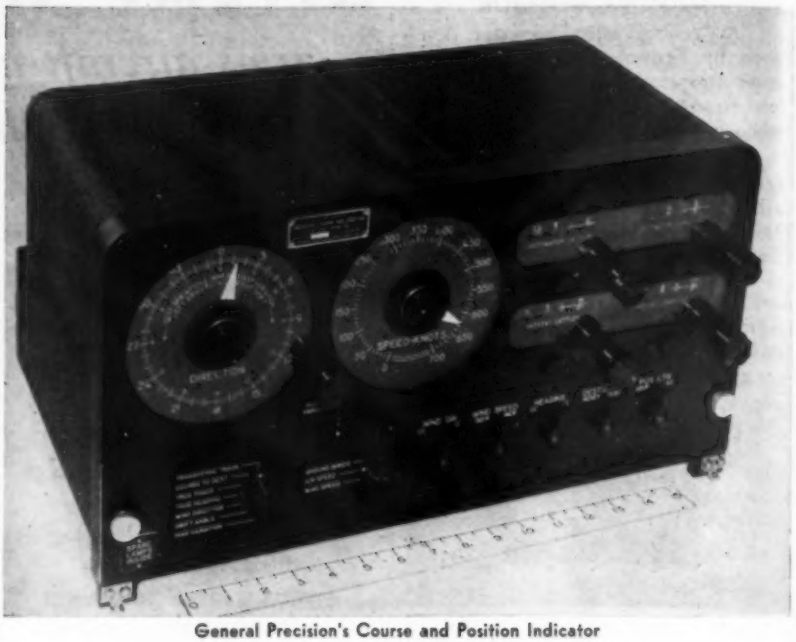
Auto-Nav Computer

data is continuously combined with compass heading to provide an instantaneous indication of aircraft position.

The system is automatic. Once the pilot operates one switch at the start of a flight, the aircraft can be flown automatically along the shortest route to destination. Aircraft position is shown on latitude and longitude counters throughout the flight.

Another system feature is a "memory" operation which permits it to compute and indicate data even if pulse contact is interrupted or temporarily shut off.

Basic components of the system are the AN/APN-88 radar (Doppler) and the AN/APA-95 navigational computer group.



General Precision's Course and Position Indicator

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Ruggedized TV Camera

Another GPL development this year is its Model PD-152 ruggedized television camera designed to withstand the extreme environmental conditions customary in flight-testing and rocket and jet test-stand operations.

The new camera weighs 6.5 lbs. and with its 35-lb. camera control unit provides a rugged, closed-circuit TV system.

As an example, GPL cites one instance in which it was lashed to an aircraft engine firewall to monitor landing gear operation during takeoff and landing. On another flight it operated successfully while mounted in the airstream on the leading edge of an aircraft wing, outboard of the No. 2 engine nacelle and just behind the propeller. Purpose was to view the exhaust stack of a Turbo Compound engine.

The camera is rated to operate under vibration and shock loads of more than 15 g's in each of its three axes. It will perform up to altitudes exceeding 60,000 ft. without additional shielding, according to GPL.

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HELICOPTER CONTROL SYSTEM

High on the list of key developments for 1956 by **Sperry Gyroscope Co.**, Div. of Sperry Rand Corp. is a miniature, fail-safe flight control system for all helicopters regardless of size.

The basic system, including automatic trim devices, altitude and speed controls, weighs 60 lbs. In one com-

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bination of controls for a medium sized helicopter the system occupies less than two cubic feet.

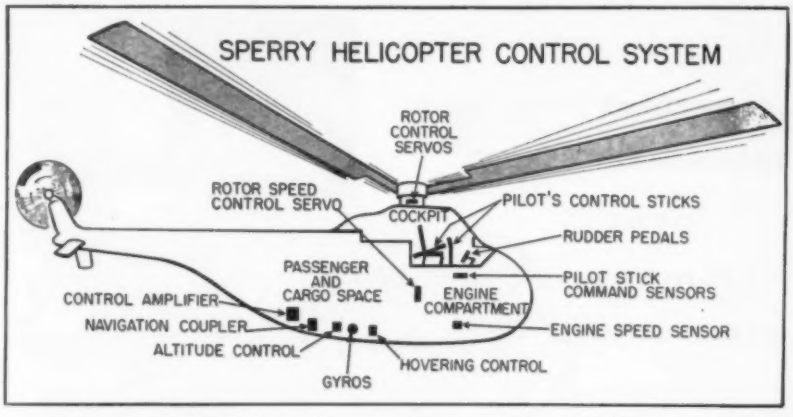
According to Sperry officials, it supplies greatly simplified manual control, or completely automatic operation for new "sky hook," or other hovering missions. The new system is the result of more than four years of development and flight testing at Sperry. In this process, the company found some of the engineering answers for stability of helicopters in other miniature control systems it has recently developed for missile guidance.

• **The system provides** five channels of automatic control through a single set of primary cockpit controls similar to the conventional stick, rudder pedals and collective pitch lever. This integrated combination, Sperry says, gives the pilot full freedom for manual maneuvering, yet simultaneously provides fail-safe automatic stability in cruise, hovering and engine-out autorotation.

Electronic "Brain Cell."

In manual-automatic operation, gyros stabilized the helicopter on its existing flight path. When the pilot applies pressure to the controls to change flight path, sensors "feel" the command and signal the automatic system.

For automatic hovering, couplers could accept signals from inertial devices in the aircraft, or from submerged sonar units, ropes, cables or



ground command signals via radio.

• **The system** also permits pilotless operation such as might be required for an unmanned helicopter to lift special devices such as a radar antenna over a tactical position. Throughout its operation, a pilot's command can override the system—such as climbing over a hill or island—later releasing the command to allow the altitude control to return the helicopter to its previously set altitude level.

For fail-safe performance, Sperry has applied redundant amplification techniques. Each electronic "brain cell" is actually two amplifiers contained in a unit not much larger than a matchbook. Should one fail, the other carries the load without an appreciable change in performance.

Should the helicopter engine fail, the system remains in operation during an engine-out glide, using a small fraction of the reserve electrical power available from the helicopter's battery.

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ELECTRONICS

JET TRANSPORT SIMULATORS

Curtiss-Wright Corp.'s Electronics Division, until now the sole U.S. producer of electronic flight simulators for commercial transports, has come up with a candidate in the simulator market for new jets and turboprops.

The C-W Dehmel simulator for both the Douglas DC-8 and Boeing 707 has been ordered by Pan American World Airways. PAA will receive one of each type with an option for two additional DC-8 and three 707 units.

• **The C-W approach** calls for analog computation using ac circuitry. The company bases its selection of ac on its superiority to dc in handling the addition and multiplication computations required in simulators. C-W grants that dc is good in small transient response for integration computation, but that ac holds the advantage for integration at larger amplitudes and for longer periods of time.

And since it considers ac superior except in flight system small-signal integration, it reports that much research has enabled it to devise an ac integrator comparable to dc.

As a further basis for using ac computation for additional functions, C-W cites these advantages to offset the lack of susceptibility to phase shift in dc units:

• No automatic checking system required.

• High efficiency—uses two tubes instead of four in dc.

• Uses one power supply instead of five.

• More compact—uses simpler, cheaper and non-selected tubes.

But use of dc, C-W says, requires highly-balanced, precisely-controlled, cross-regulated power supplies, requires automatic drift and balance checking circuitry, calls for more critical tube selection, and requires a separate amplifier for inverting signal phase, thus increasing by many dozen the number of amplifiers needed.

• **C-W further cites** the advantage

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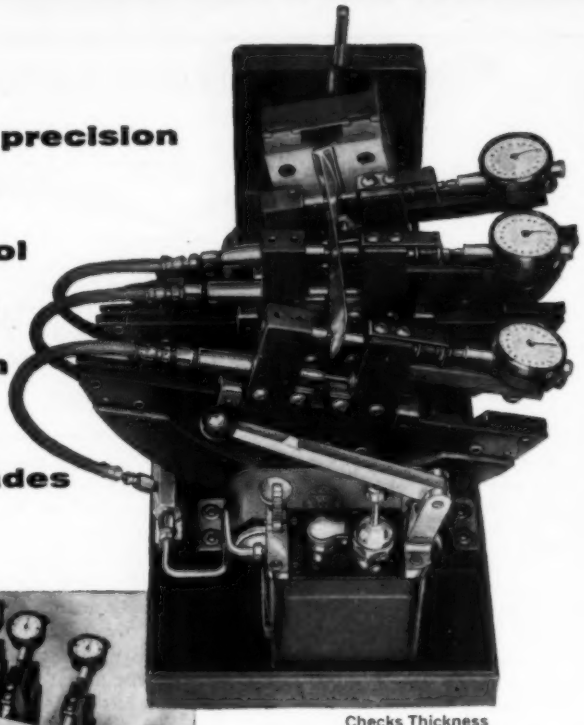
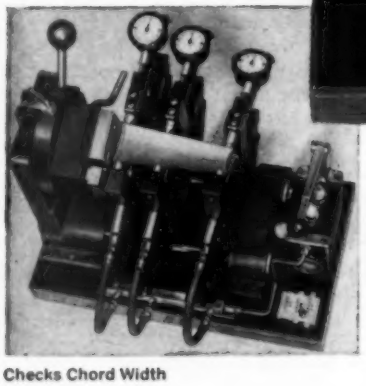


Checks Thickness



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of ac circuit simplicity for multiplication functions, and says its recently developed parallel ac/dc integrator exhibits the principal advantages of each circuit type for integration functions.

Simulators for the Boeing 707, DC-8 or Lockheed Electra are being so designed, C-W adds, that engine changes can be readily accomplished by substituting new contoured potentiometers and plug-in resistors as required. A highly accurate jet engine simulator it has evolved features 1/9th the complexity of competitive simulators, Curtiss-Wright says.

Specifications for the Dehmel units being constructed for PAA will have a built-in "growth" factor. For example, the aircraft gross weight adjustment and computation will encompass the range from 136,000 to 320,000 lbs., almost 30,000 lbs. higher than the top gross so far mentioned for either the 707 or DC-8.

In simulating Pratt & Whitney's J75 engine, the C-W simulator will provide for growth up to 18,000 pounds thrust.

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FLIGHT SIMULATOR

Link Aviation, Inc. this year launched its bid for the commercial jet transport flight simulator market with a new approach to simulation—the use of dc instead of ac computation.

The change to dc, rated by Link as its top 1956 development, is based on a number of analog computer performance factors it feels show advantage to dc in simulator design. As a result, DC-8 jet transport simulators now being built for Douglas Aircraft Co., United Air Lines and Scandinavian Airlines System will be of that type.

In support of its shift to dc Link points to the results of a Univ. of Michigan study for the U.S. Air Force and an analysis by E. O. Gilbert, of Univ. of Michigan's department of aeronautical engineering, of computation in flight simulators.

• **Gilbert points out** that only in the field of flight simulators is there continued use of ac. He points to early development of analog computers, both in the "Cyclone" project at Reeves and "Typhoon" project at RCA. Reeves started with an ac system that was dropped after some time and both companies eventually settled on dc systems.

Another factor cited by Gilbert is the simplicity by which a built-in checking system can be made available in a dc system to monitor computer performance in the complex simulator. In a dc simulator only a dc voltmeter is needed to handle this task, whereas on ac computers both phase and amplitude of a voltage are important, making

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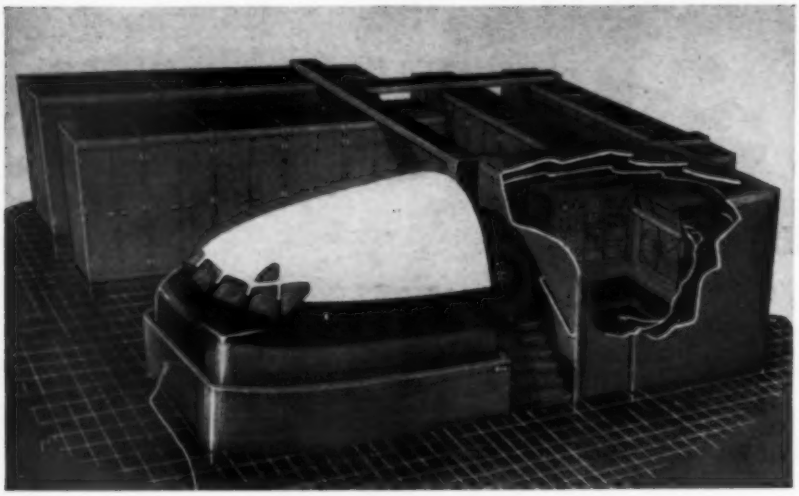

the check system more complex.

Basic difference of the two systems is the approach used to represent the problem variables of flight simulation. In an ac system, these are represented by the amplitude of an ac voltage, usually 60-cycle. Positive signals are distinguished from negative signals by a reversal in phase (180° shift) of the ac voltage.

• **In a dc system,** the variables are represented by the magnitude of the signal. Positive signals correspond to a positive voltage and negative signals to a negative voltage.

One disadvantage of dc amplification, Gilbert notes, is their drift. However, in high-quality amplifiers he feels this may be kept below 1/100th volt for long periods of time without adjustment, resulting in an effect on simulator operation that could not be discerned by the pilot.

The ac amplifier does not suffer from drift, Gilbert adds, but does have unwanted inputs from stray coupling. These he considers to be more serious than drifts in the dc amplifier.

COLLISION WARNING

At **Collins Radio Co.,** development highlight is its proposal for (1) an aircraft proximity warning system and (2) a collision avoidance system, both winning support by a special airline committee as offering the most promising solution to the mid-air collision hazard.

The Collins system, employing FM-CW Doppler radar techniques, will be available in prototype form by early 1958. It will give the pilot a warning light indication of an aircraft intruding into any one of six quadrants around the equipped plane—fore or aft, right or left, above or below.

The proximity warning unit will have a range of two miles during cruise with an alternative selection of 800 ft. for high-density terminal operations where the two-mile coverage would unnecessarily warn of aircraft normally operating that close.

Collins engineers estimate the "black box" for the system will occupy a full ATR, weigh about 55 lbs. and cost approximately $9,300 per copy plus installation expense.

• **The ultimate system** will go a step beyond the "look and see" warning provided by the first-phase equipment. It will signal the pilot of approaching aircraft and simultaneously compute and direct proper maneuvers for evasion.

Another Collins development is its

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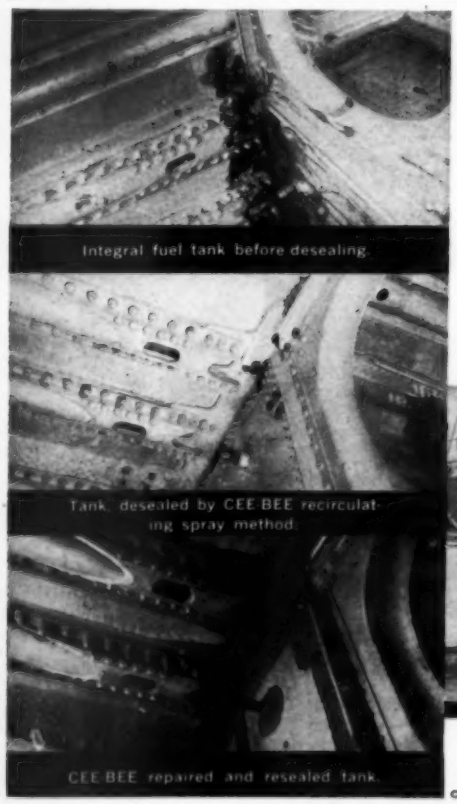
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FD-105 Flight Director System employing new circuit designs that use magnetic amplifiers and transistors, with no need for vacuum tubes.

Collins IFS (integrated flight system), in its latest development, features easy-to-read 4″ course indicator and approach horizon and two ¼ ATR cases for computer and servo amplifiers. Total weight is 31.5 lbs. and power requirements 116 va start and 110 va running.

Circle No. 7 on Reader Service Card.

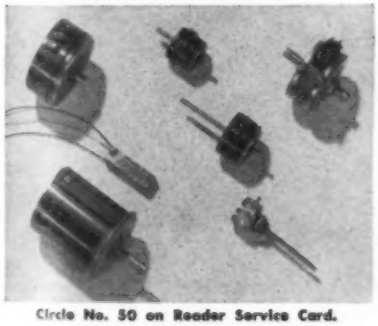
POTENTIOMETERS

First phase of a research program by **Fairchild Controls Corp.** to develop a complete line of 500°C potentiometers was marked this year by the introduction of units rated up to 225°C.

About eight years' research effort and $300,000 have been invested in the program, according to Fairchild officials.

The new series includes wirewound potentiometers in both single and multi-turn types which are rated for continuous duty at 125°C—¾ to over 4 watts, with 0.1 watt or more at 150°C, depending on size and type.

They are available in ⅞″, 1⅛″, 1¾″ and 2″-diameter linear and functional types, and both a ten-turn and three-turn $1\frac{3}{16}$″ diameter unit.



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MAGNETIC ANTENNA

General Bronze Corp., Brach Electronic Division has announced the culmination of an intensive research program with development of a magnetic aerial it feels will miniaturize aircraft antennas for receiving purposes.

The new unit serves as a sense antenna for the ARN-6 direction finder and can be used as a general receiving antenna for frequencies up to and including 5 megacycles. It can also be designed to perform efficiently at frequencies down to 100 kilocycles.

Magnetic aerials have not been used for aircraft prior to the General Bronze development because of their highly directional characteristics when employed with standard circuitry, says Brach's v.p. research Ira Kamen.

But with the newly developed circuitry and magnetic material orientation, Kamen points to these achievements with miniature magnetic components:

- A non-directional antenna that employs high Q material.
- An antenna with a much higher signal-to-noise ratio pick-up than the standard metal capacitive antenna.
- As a sense antenna, an optimum sensitivity that allows adjustment of the signal level pick-up to be comparable to the loop pick-up sensitivity on the full operating range.

Further, as a sense antenna, Kamen says the new unit provides the same phase signal regardless of polar position, thereby assuring performance of the sensing function. And, he adds, all of these specifications are realized

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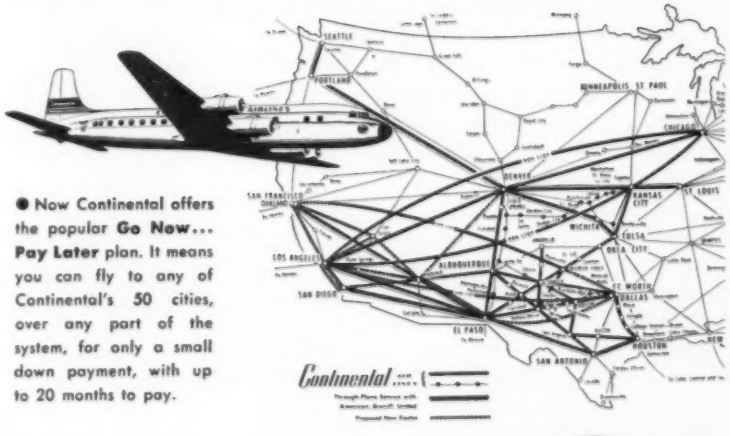

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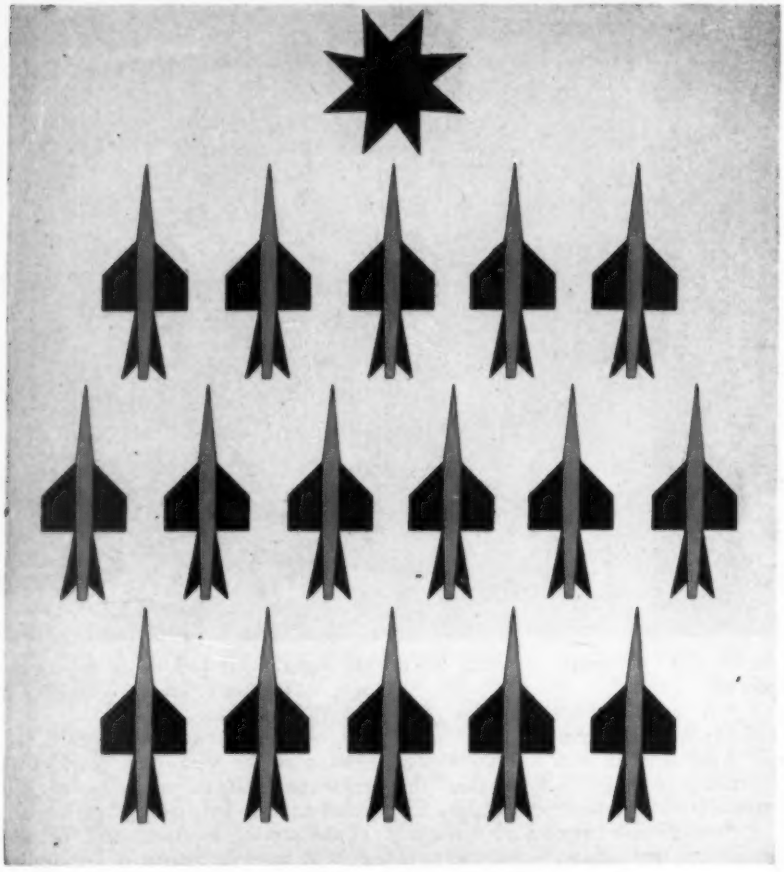

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with an antenna that can function in an area that may be considerably less, but not larger, than 10″ x 10″ x 2″.

With this combination of higher signal-to-noise ratio, less susceptibility to interference pick-up, miniaturization and weight reduction, General Bronze officials are convinced its magnetic aerial looms as a certainty for application to both current and future aircraft.

Circle No. 57 on Reader Service Card.

MINIATURIZED ADF

Key new development at **Aircraft Radio Corp.** is its Type 21 miniature automatic direction finder, introduced after more than a year of flight testing.

The 19.1-lb. ADF is a 3-band superheterodyne receiver complete with power unit, receiver, control unit, indicator, loop, loop housing and all connectors.

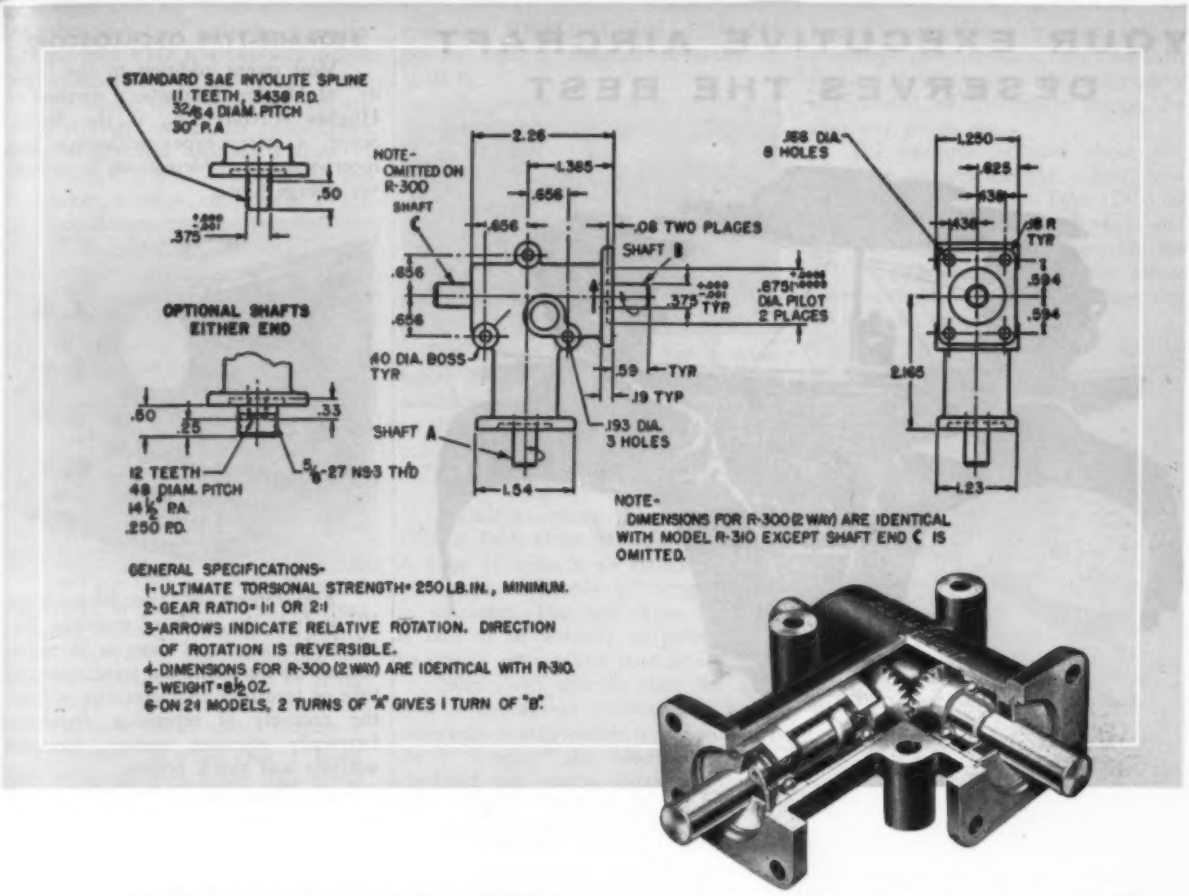
The Type 21 provides reception of and direction on LF range and broadcast stations in the 190 to 1750 kc spectrum. It uses a hermetically-sealed loop that penetrates only 1¾″ beyond the skin of the aircraft.

The new ADF incorporates 14 premium-type subminiature tubes with conservative dissipation derating, giving the Type 21 a sensitivity and selectivity comparable to commercial and military equipment weighing three times as much, according to company officials.

Here's how ARC sizes up factors favoring use of the Type 21:

- Low frequency ADF is especially suitable in low-altitude flying where line of sight is restricted.
- Some airports have only LF or broadcast facilities and the Type 21 can be used with either.
- It has the unique ability to localize the source of any continuous r-f signal in its tuning range.
- It can serve as prime navigation unit in the lightest aircraft.
- It can supplement VOR and a lightweight VHF communications unit in larger planes.

Circle No. 23 on Reader Service Card.



HOW TO MAKE A RIGHT-ANGLE BEVEL GEAR

Need a right-angle gear drive? You can make one yourself. Here's all you need: a set of Coniflex* gears, a precision-cast housing, antifriction bearings, and shaft extensions. Put these together, lubricate the unit for life, test it for quietness (noise means future trouble), and you have a right-angle drive. Too expensive, you say? That's why we would urge you to buy ANGLgear, a compact, standardized take-off that has won the respect of designers everywhere.

Trade-mark The Gleason Works, Rochester, N.Y.

Model & Type	Ratio Turns "A" to Turns "B"	HP Output	RPM Shaft "B"	Ultimate Static Torque (lb in)	Shaft dia (Inches)	WT (lb)
R-300 2-way	1:1	⅓	1800	450	⅜	½
R-300-2 2-way	2:1	⅓	1800	450	⅜	½
R-310 3-way	1:1	⅓	1800	450	⅜	½
R-310-2 3-way	2:1	⅓	1800	450	⅜	½
R-320 2-way	1:1	1	1800	1500	⅝	2.2
R-320-2 2-way	2:1	1	1800	1500	⅝	2.2
R-330 3-way	1:1	1	1800	1500	⅝	2.4
R-330-2 3-way	2:1	1	1800	1500	⅝	2.4

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STORAGE-TYPE OSCILLOSCOPE

Most recent addition to the "family" of Hughes Products, a division of **Hughes Aircraft Co.,** is the Memo-Scope, a storage-type oscilloscope that incorporates the Memotron, a cathode ray storage tube.

Applications of the Memo-Scope 103 include the study of transient electrical phenomena, as short as 10 microseconds in duration; the presentation of tube or transistor characteristics without the necessity of repetition displaying frequency response curves; spectrum analyses and shock testing.

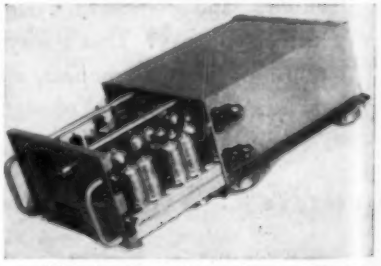
The Memo-Scope forms and retains traces at constant intensity until they are deliberately erased. This is accomplished by a storage "mesh" immediately behind the viewing screen. Electrically charged wherever it is struck by the writing electron beam, the mesh retains the charge pattern locked in place.

The stored trace is immediately visible on the phosphor-coated face of the tube of a 5-kv accelerating potential between the mesh and the screen. It is visible even in a brightly lighted room and may be easily photographed.

The Memo-Scope is available in portable and rack-mounted models.

Circle No. 48 on Reader Service Card.

VHF-FM COMMUNICATIONS



Nomination by **Communication Co., Inc.** for its front-line 1956 development is its 22-lb. Model 400 12/24 VHF-FM two-way radio unit designed for operation in aircraft with 12- or 24-volt systems.

It is intended for executive and utility aircraft used by power, petroleum

and other industrial activities maintaining their own VHF-FM two-way mobile radio systems.

The Model 400 consists of a crystal-control receiver, transmitter and vibrator power supply and occupies a space of 14" x 11½" x 6½". Installation, less the speaker, antenna, etc. weighs 20 lbs.

The Comco unit is supplied for both 25-54 megacycle and 144-174 mc bands and is obtainable for 72-76 mc use on special order. It is mounted on an ATR-type shock mount but is not of standard size.

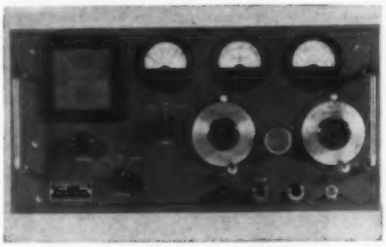
Circle No. 41 on Reader Service Card.

TELEMETRY RECEIVERS

Newest in the line of special-purpose receivers developed by **Nems-Clarke, Inc.** for guided missile telemetry is the Type 1400, a crystal-controlled unit operating in the 216-245 megacycle range.

The Type 1400 features a choice of two second IF amplifiers of different bandwidth selected by means of a switch on the front panel. The wide-band amplifier has a bandwidth of 500 kc at the 3 db points, with an attenuation of 60 db 500 kc each side of center frequency.

The other amplifier has a bandwidth of 100 kc with better than 60 db attenuation 250 kc each side of center frequency. It is primarily intended for receiving PWM/FM and PTM/FM signals with a nominal deviation of ±50 kc.



The Nems-Clarke unit has a noise figure of less than 7 db and, with minor modification, is slated for extensive use on the Vanguard satellite program.

Circle No. 42 on Reader Service Card.

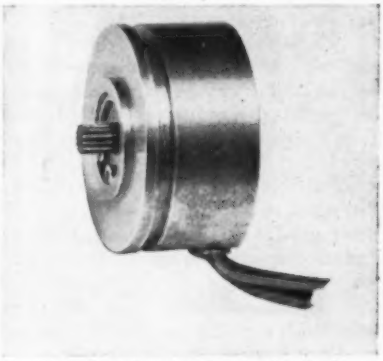
SERVO MOTOR

Standout among developments in 1956 at **John Oster Manufacturing Co.** Avionic Division is an extremely short servo measuring only ½" long and 1" in diameter. The new Type 2V-3362 is said to be virtually as powerful as its size 10 servo which is twice as large.

John Oster officials class the new unit as by far the shortest ever built. Although exactly one-half the bulk of the 1" long, 1" dia. Model 10, it has one-third the torque but one-half the rotor inertia.

Since the torque and rotor inertia factors about offset each other, and remaining characteristics are basically similar, an unusually high performance is indicated for the smaller motor, the company points out.

For example, it cites these performance features. On the —55°C low-temperature test, the Type 2V-3362 starts with 18 volts on fixed phase and with 0.8 volts on control phase. On the 71°C high-temperature test, the motor starts with 18 volts on fixed phase and 0.5 volts on control phase.

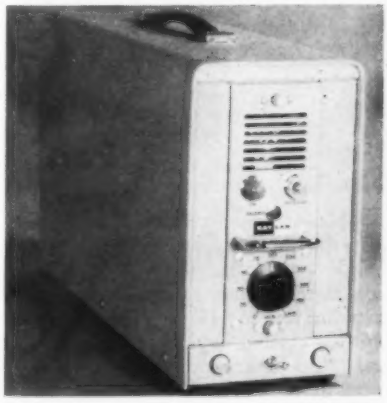


Circle No. 33 on Reader Service Card.

D-C AMPLIFIER

The Model 111 d-c amplifier, designed for telemetering, data reduction and instrumentation using transducer measuring systems, is the choice of **Kaylab** as its foremost aviation contribution this year.

According to Kaylab officials, the Model 111 provides the lowest drift of any commercially-available broadband d-c amplifier, making practical dynamic, high-accuracy d-c strain-gauge systems.



It features a 2-microvolt drift, extremely low noise, high input impedance and low output impedance. Output is ±35 volt, ±40 milliamps.

Use of d-c strain-gauge systems, according to Kaylab, offers greater accuracy, operational simplicity and reduced maintenance. Officials cite one installation in which Kaylab d-c amplifiers have logged more than a million hours of accurate, trouble-free operation.

Circle No. 43 on Reader Service Card.

AVIATION GAS PRICES REDUCED 4½¢ A GALLON IN PENNSYLVANIA!

The Commonwealth of Pennsylvania calls the attention of carriers and executive and private plane owners to the fact that the tax on aviation gasoline throughout Pennsylvania has been reduced from 6c to 1½c per gallon—a savings of 4½c on every gallon! It is our sincere hope that this reduction will bring you greater convenience and lowered costs of operation.

WILLIAM R. DAVLIN, *Secretary*
DEPARTMENT OF COMMERCE
COMMONWEALTH OF PENNSYLVANIA
HARRISBURG, PENNSYLVANIA

Circle No. 147 on Reader Service Card.

ELECTRICAL

Top contribution by **Hetherington, Inc.** to aviation in recent months is a complete series of moisture-proof, momentary-contact pushbutton switches for use in machine gun and trim tab controls as well as canopy, bomb and autopilot release mechanisms.

The Hetherington Series W100 are designed to Spec. MIL-S-6743 and may be fitted with any of eight different anodized aluminum mounting adapters to meet varying requirements.

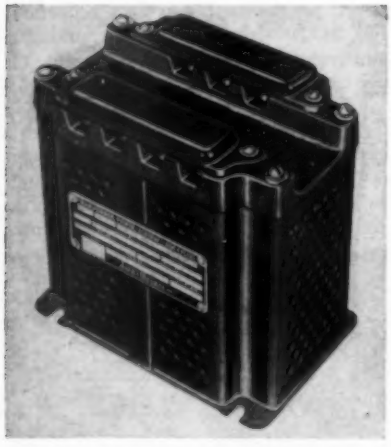
W100 switches are provided in six different contact arrangements—SP-ST normally-open; SP-ST normally-closed; two-circuit; 3-terminal normally open; three-terminal normally closed; and SP-DT.

Switches vary from 9/16 to 7/8" in diameter and from 1 11/32 to 2 9/32" in length. Weight for all types except limit-switch applications is about 0.25 oz.

The type adapter used for limit switches brings the weight to approximately 0.75 oz.

Circle No. 11 on Reader Service Card.

A-C TRANSFORMER



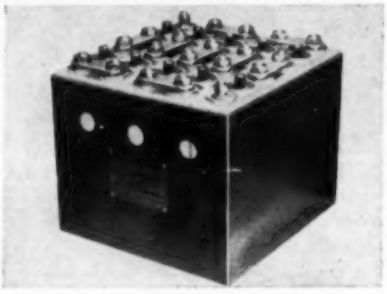
New venture for **Jack & Heintz** in 1956 was the development of the Model GC150 power transformer for conversion of three-phase a-c power from 200 volts line-line to 115 volts line-line. The unit has entered service on Boeing B-47s and MD-3 ground power units.

The GC150 weighs 6.5 lbs. and is rated at 1.5 kva with a 0.8 power factor. Its guaranteed efficiency is 93% compared to 86% specified by Spec. MIL-T-9219 and regulation at rated load is within 4%, well below the 6% specified.

Circle No. 40 on Reader Service Card.

NICAD BATTERIES

Nickel Cadmium Battery Corp. has unveiled a series of miniature nickel cadmium batteries ranging in capacity from ½ to more than 150 ampere hours. Using sintered-plate construction, they are designed to produce high cranking currents for starting jet and piston engines.



The Nicad batteries are said to deliver momentary discharge currents as high as 25 times their rated amp./hour capacity and to meet their useful capacity at temperatures extending from —40° to 165°F. They can be stored indefinitely in any state of charge without deterioration or exposure to freezing.

Plate construction consists of porous sintered nickel impregnated with nickel and cadmium oxides. Electrolyte is a solution of potassium hydroxide. Cell containers are of high-impact plastic grouped in steel cases to form batteries.

Circle No. 26 on Reader Service Card.

MINIATURIZED CONNECTORS

Amphenol Electronics Corp. considers its development of the Micro-Ribbon series of connectors for airborne electronics equipment its No. 1 contribution to aviation in 1956.

As an example of the miniaturization achieved, company officials give this comparison of the new development with its standard series of Blue Ribbon connectors:

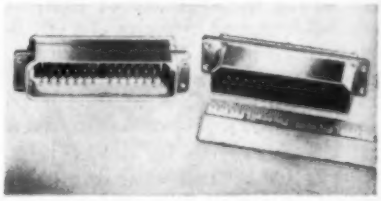
The weight of 240 circuits using 10 mated pairs of standard Ribbon connectors is 1½ lbs. and requires 48 cu. in. of space. The same number of circuits using Micro-Ribbons weigh only ½ lb. and occupy only 10 cu. in. of space. This amounts to a weight reduction of 66% and a space saving of 79%.

The Micro-Ribbon connectors are rated at 700 volts d-c at sea level and 200 volts at 70,000 ft. They are available with 14, 24 or 36 contacts.

Circle No. 22 on Reader Service Card.

CANNON CONNECTOR

Top rating at **Cannon Electric Co.** among 1956 developments goes to its new DPE rack and panel series of electrical connectors.



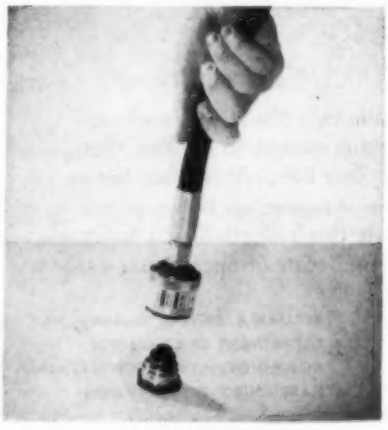
First of the new model, a 40-contact design, has a total weight of 0.381 lbs. including both the socket and pin insert assemblies. Forty of the 10-ampere solder pot contacts for a No. 16 stranded wire have been placed in a Melamine (Melmac) No. 1502 insulator.

Flashover for the DPE series is rated at 1,700 volts, 60 cycle a-c rms at sea level. Shell is of diecast aluminum and has an overall length of 3 15/16 in.

Circle No. 16 on Reader Service Card.

HARDWARE

An automatic, quick-connect, self-sealing coupling for high and low pressure hydraulic and pneumatic lines is the choice of **E. B. Wiggins Oil Tool Co.** as its most significant development this year.



The Wiggins Connect-O-Matic has been tested to no less than 15 government and airframe manufacturers' hydraulic specifications.

According to Wiggins, positive valve action assures complete flow when connected and no leakage when disconnected.

New Sta-Bak actuating rings used in the fittings allow visual inspection and eliminate all chance of an incomplete connection.

A simple push on the tube or end automatically connects the coupling and a "click" is further indication it's complete.

By pulling on the actuating ring, the coupling is disconnected without the need for twisting action or tools.

Connect-O-Matic is produced in a

full range of sizes from ¼" through 1½" with a variety of AN and MS ends. Literature available.

Circle No. 3 on Reader Service Card.

TITANIUM BELLOWS

Titeflex, Inc. has successfully produced a series of titanium welded bellows ranging in size from 1" to 3½" I.D. and from four to 12 convolutions in construction. Units are rated to operate at pressures from 50 psi to 400 psi.

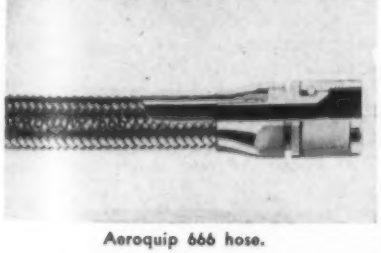
Material used by Titeflex in typical units produced to date includes Rem-Cru A70 and A110 AT titanium. Actual bellows are individually engineered to customer needs.

Unit pictured is a 3" I.D. design for 315 psig proof pressure which burst under test at 750 psig.

Circle No. 25 on Reader Service Card.

HOSE AND FITTINGS

Heading the list of new product developments by **Aeroquip Corp.** this year are its Series 3200 self-sealing couplings for 3,000-psi hydraulic systems and Type 666 Teflon hose with "super gem" fittings.



Aeroquip 666 hose.

The Series 3200 coupling is made up of two coupling 'halves' and a quick-lead union nut. Valves in each coupling half are designed to open simultaneously with locking action so that there is no intermediate stage where it is partially open or closed.

In all, the new coupling consists of 13 parts plus O-rings and Teflon back-up rings. It is rated for use in aircraft and engine hydraulic systems up to 3,000 psi at 275°F.

• At **present,** the Series 3200 is available in a —8 size, but sizes —4 through —24 are slated for production.

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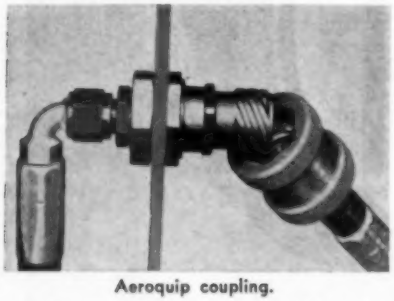
Circle No. 144 on Reader Service Card.

The —8 coupling weighs .664 lbs.

Aeroquip's new Teflon hose with "super gem" fitting is designed for use with a variety of aircraft and missile fluid systems at temperatures ranging from —100°F to 500°F. The Teflon hose inner tube in the Series 666 is said to be unaffected by any known fuel, oil, alcohol, coolant, red or white fuming nitric acid and other acids.



Aeroquip coupling.

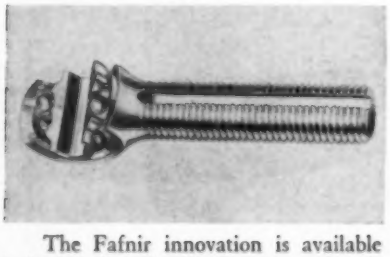
In the Series 666 assembly, the Teflon inner hose is reinforced with a stainless steel wire braid for resistance to corrosion. The new hose is available in sizes —3 (⅛ I.D.) through —16 (⅞ I.D.) with weights ranging from .041 to .305 lbs./ft.

Circle No. 55 on Reader Service Card.

AIRCRAFT BEARINGS

A new series of "balanced" rod end control bearings is rated by **The Fafnir Bearing Co.** as its biggest contribution to aviation in 1956.

The new bearings are the outgrowth of a National Aircraft Standards Committee study in which company engineers participated. They feature a bearing design in which load capacity, shank strength and bolt strength are in balance.



The Fafnir innovation is available in both ball and roller bearing rod ends having male-threaded shanks. The two ball-bearing rod ends with high-strength shanks are designed primarily for manually-operated control systems.

Completing the series are three high-capacity roller-bearing rod ends for power-operated flight control systems. Literature available.

Circle No. 6 on Reader Service Card.

TEFLON HOSE

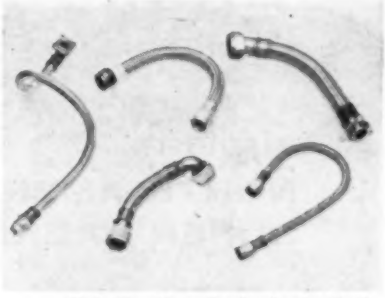
Resistoflex Corp. has introduced two new features in its production of Teflon aircraft hose, a preformed version of its Fluoroflex-T series hose and a 3,000-psi hose in this same series.

The preformed assemblies are shaped at the factory to stress-relieve the hose at all bends and are designed to permit much tighter bend radii than possible with free hose. As a result, according to Resistoflex, they save space and weight by permitting installations to clear obstructions using the shortest possible lengths.

The new Fluoroflex-T hose for 3,000-psi duty uses an inner tube of a special compound of Teflon with two wire braids for reinforcement in sizes —4, —6 and —8. A three-braid design in size —10 is under development and is already available in size —12.

Inner braids are of cadmium-plated, carbon steel separated by a thin Teflon interlayer. Outer braid is type 304 stainless steel for corrosion resistance.

The hose is rated for operation through a temperature range of —65° to 400°F and is said to be unaffected by all fuels, oils, alcohols and solvents.

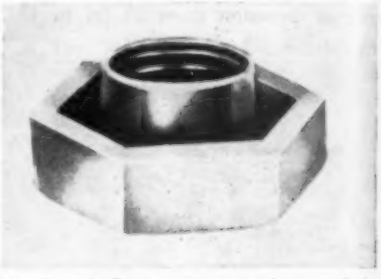


Circle No. 14 on Reader Service Card.

SELF-LOCKING HEX NUT

Latest in developments by **The Kaynar Co.** is a lightweight hex nut that can be wrenched internally or externally designed for aircraft, missile and electronic applications.

The H10 series nut is available in sizes 4-40 through 5/16-24 and conforms to AN-363, AN-364 and AN-365 standards. According to Kaynar, several major aircraft firms are converting to their use with weight savings of more than 100 lbs. per plane resulting even on relatively small combat types.



The new hex nut is rated for operating temperature ranges of —100° to 550°F.

Big feature of the low-height, in-and-outside wrenching design is its use where space is at a premium and clearance is insufficient for conventional wrenching. With the H10, Kaynar says, the nut may be nestled closer to adjoining structure thereby allowing substantial reduction in spotface diameters and flange widths.

Circle No. 13 on Reader Service Card.

TEST EQUIPMENT

Four new items of test equipment, all related to the military's Tacan navaid, soon to be integrated into the "common system" for civil distance measuring, are rated among standout developments by **Hoffman Laboratories, Inc.**

Hoffman's HLI-103 beacon simulator tests Tacan airborne equipment by simulating all functions normally presented by ground stations. It can be used to check out equipment while installed in the aircraft or on a test bench.

HLI-103 is housed in a single case measuring about 40½" high, 19" wide and 21" deep and weighs about 300 pounds.

In simulating the ground portion of Tacan, the test unit provides these features:

- Continuously variable azimuth data from 0 to 360° at an accuracy of ±0.2° or better.
- Range simulation in six steps—0, 24, 48, 72, 96 and 192 nautical miles, with an accuracy of ±0.1 mile or better.
- Continuously variable range data from 0 to 200 n.m.
- Beacon identity tone simulation.
- Operation on any of 126 crystal-controlled channels.

The HLI-103 also simulates aircraft speed—toward or away from the beacon—at any selected figure between 0 and 1,500 knots. Adverse atmospheric con-

ditions are fed in via a range-reply probability circuit which varies reply possibilities anywhere from 10 to 90%.

Confidence Checker

Still in development at Hoffman is the HLI-110, a 15-lb. flight line tester that provides one or two azimuth bearing checks and one or two range position checks on the flight line.

The HLI-110 could be operated on a pre-selected channel, but primarily it will be designed for one-channel operation. If one high and one low channel are required, this feature can be provided by additional circuitry.

Portable Simulator

Another Tacan tester is the AN/-ARM-25, a sub-miniaturized instrument to check out airborne equipment as to range, bearing identification signals. It contains 69 electron tubes in a carrying case that measures 11″ x 14″ x 18″ and weighs 40 lbs.

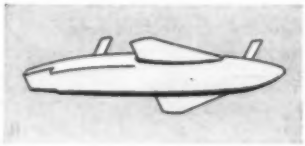
Internal arrangement of the AN/-ARM-12 includes 12 sub-units each for checking some particular phase of Tacan operation.

Book Testers

Hoffman also developed a series of "book testers" used as a production aid for checking out the so-called books or sub-assemblies that make up the complete Tacan system. These units have proven readily adaptable to the needs of military depot overhaul and repair activities and field testing.

Eight separate testers are used—each a complete, self-contained unit capable of complete check-out of its related book. The individual items include a video decoder test set; azi-

Even the hot desert sands offer no landing problems to aircraft whose design includes the Pantobase landing system. A product of Stroukoff research and development, Pantobase will permit landings and take-offs from snow, ice, sand, water and unimproved terrain; thereby extending the operational capabilities of the aircraft and reducing the need for conventional airports in many remote and previously inaccessible parts of the earth's surface.



Pantobase—When designed into an aircraft the Pantobase system enables the plane to land and take-off from many types of surface without changes or additional landing equipment.

BLC-Boundary layer control as developed by Stroukoff increases the effective lift and delays stalling of the wing, thereby reducing required speeds and distances for take-offs and landings.

Achievement is a tradition at Stroukoff. A leader in the development and design of cargo and transport aircraft, Stroukoff offers challenging opportunities to creative engineers.

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Here's why Curtiss-Wright engineers choose PANELOC.

STRENGTH-WEIGHT RATIO! The strength of PANELOC Panel Fasteners is so far in excess of requirements of governing specifications that fewer fasteners are required to do a particular job. This saves the weight of extra fasteners.

LONG LIFE! PANELOC Panel Fasteners are still operative when baffles and ducts wear out. Maintenance is thereby reduced to a minimum. The need for replacements is virtually eliminated.

ECONOMY! The cost of extra fasteners is eliminated and the cost of installation and maintenance reduced when PANELOC Panel Fasteners are used.

Write for catalogues and price lists on Styles 1, 2 and 3 Panel Fasteners.

A product of SCOVILL

Scovill Manufacturing Company, Aircraft Fastener Div.
44 Mill Street, Waterbury 20, Connecticut

Circle No. 146 on Reader Service Card.

muth control, azimuth gate and IF amplifier test sets. Others include a frequency multiplier and RF oscillator tester, a modulator and power supply tester, electronic range gate tester and electronic range control tester.

Circle No. 17 on Reader Service Card.

Ground Equipment

Industrial Acoustics Co., specialist in jet engine noise suppression, has come up with a new adapter for its muffling system that cuts ground noise from a Republic F-84 by 30 to 35 decibels.

Original muffler design (AMERICAN AVIATION, March 12, p. 38) used an aircraft-to-muffler adapter with one-foot

Old muffler adapter.

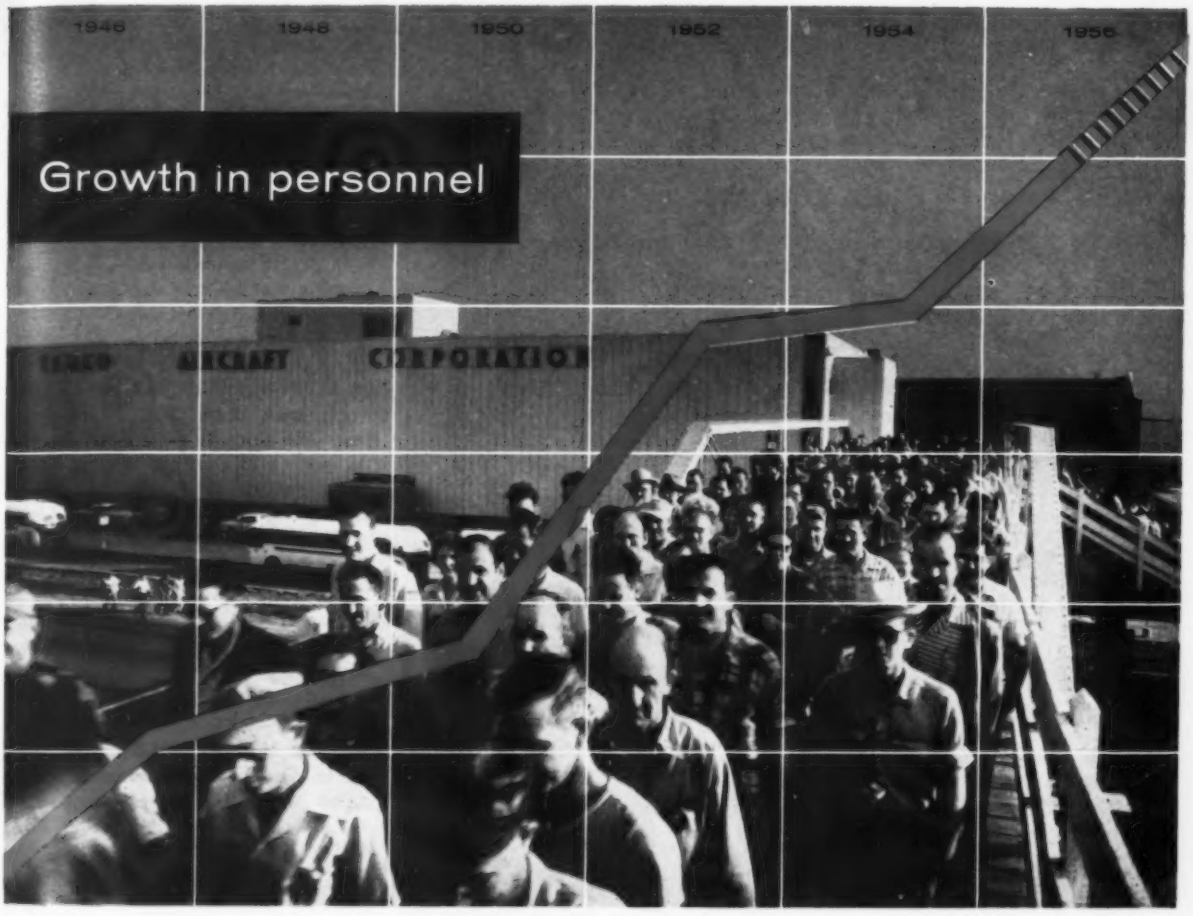
clearance to allow for aircraft motion during ground run-up. However, Republic engineers have since developed a tie-down system that reduces aircraft motion to one inch and permitted use of a close-coupled adapter between plane and silencer.

• **The new adapter** is designed acoustically so that the noise levels at the side and front of the aircraft will nearly match the muffled exhaust noise

New muffler adapter.

aft. A significant feature is that the noise level at a distance of 100 ft. in the aft quadrant does not exceed 98 decibels in the first two octave bands and does not go beyond 87 db for all higher frequencies.

IAC states that its new adapter and



At TEMCO growth tells the story!

Growth — in personnel, for example, tells the Temco success story.

In 1945, Temco had 259 employees. Today, Temco has over 10,000 employees — at three integrated Texas plants — at work on contracts covering fourteen of the country's key military aircraft. Constant expansion in every department has equipped Temco to meet the increasing needs of the aircraft industry—to push ahead the company's own developments in electronics and in aircraft and weapon systems.

Temco's sturdy growth — in skills, facilities and experience — opens up outstanding opportunities for a complete range of engineering talents. If you are looking for a rewarding career in aviation, you will find it at Temco.

ENGINEERS

Openings in all phases of aircraft design and development. Write to Joe Russell, Engineering Personnel, Room 10-A, Temco Aircraft Corporation, Dallas, Texas.

TEMCO
AIRCRAFT CORPORATION, DALLAS

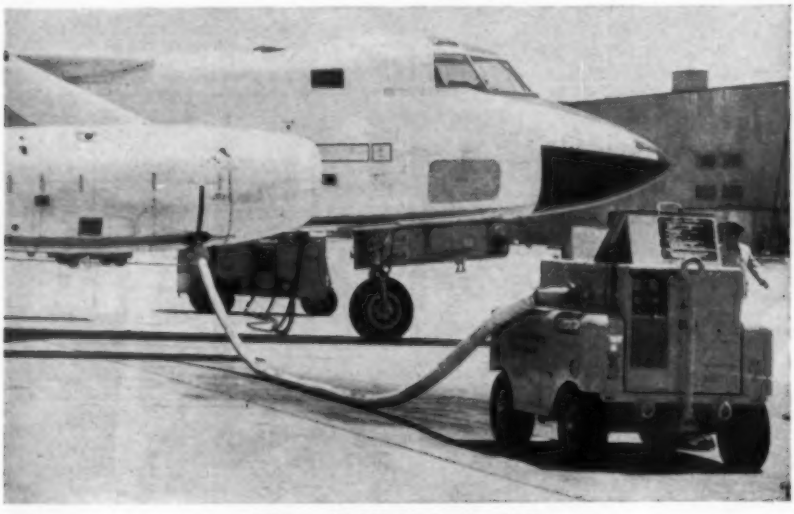
IN ENGINEERING THE BEST OPPORTUNITIES ARE IN AVIATION • IN AVIATION THE BEST OPPORTUNITIES ARE AT TEMCO

Dura-Stack muffler provides 30-db all-steel, semi-portable system for less than $25,000.

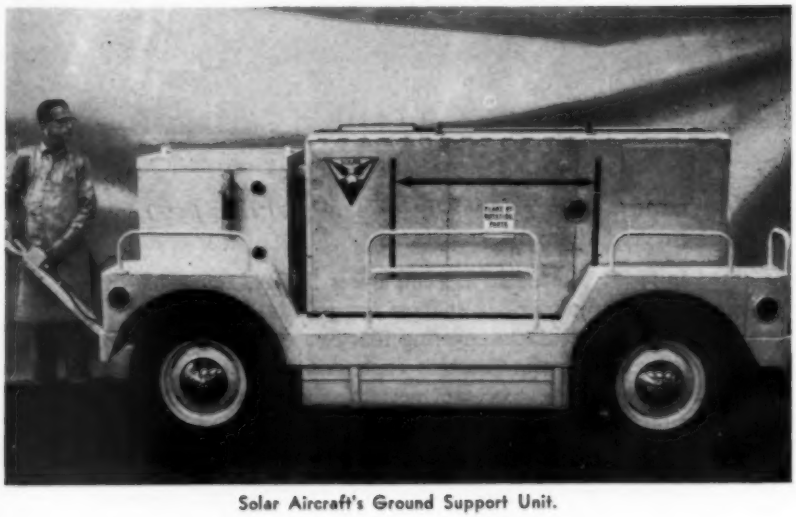
The present Dura-Stack muffler for the F-84 and Wright J65 jet engine combination is of sufficient capacity to handle the more powerful Pratt & Whitney J57 engine with the addition of water cooling. Sketch shows the noise spectrum surrounding an F-84F with and without muffler.

Circle No. 46 on Reader Service Card.

JET STARTERS



AiResearch's MA-1A Starting Unit.



Solar Aircraft's Ground Support Unit.

AiResearch Starter

Product highlight at **AiResearch Manufacturing Co.** of Arizona for 1956 is the development and qualification of its MA-1A trailer unit, said to be the first gas turbine compressor trailer-mounted starting unit to pass complete qualification tests and be accepted by the Air Force.

The MA-1A is a completely self-sufficient pneumatic power source for starting jets and supplying compressed air. Powered by a 190-lb. small gas turbine, it can start any military or commercial turbine aircraft that is fitted with pneumatic starters.

And with air delivered in the 350° to 500°F range, it also has been effectively used for ground de-icing purposes.

• **The MA-1A** is completely automatic. A bleed airflow of 120 lbs./min. at 50 psi is delivered 10 sec. after the start switch is operated. Normal load for the unit is 170 air horsepower with a governed speed of 43,000 rpm. The compressor is a two-stage centrifugal type with a can-type combustor and a single radial inflow power turbine.

The complete AiResearch unit is housed in a 4-wheel trailer, weighs only 1,150 lbs. and is easily transportable by air. Cart carries a 40-gal. fuel tank, a boost pump which supplies fuel at regulated pressure, 24-volt battery, and a 30-foot flexible bleed air duct fitted with a quick-disconnect coupling for attachment to the aircraft.

The MA-1A is designed for top efficiency at temperatures between —65° and 130°F at altitudes extending above 6,000 ft. It also includes a parallel manifold in which the output of two MA-1As can be coupled.

Circle No. 4 on Reader Service Card.

Solar Support Unit

During 1956, **Solar Aircraft Co.** has come up with an adaptation of its Jupiter shaft power gas turbine engine to a new bleed-air compressor for aircraft ground support.

The Model T-300J-2 produces 260 air horsepower output and can be used for engine starting and ground support for air conditioning and air turbine driven accessories. It requires only fuel and a dc power source for starting and can be mounted on a dolly or multi-purpose vehicles.

The Model T-300J-2 was developed under Air Force contract and is designated the MA-2 compressor pack. It weighs 1,500 lbs. and measures 84″ x 41″ x 37″.

The Jupiter engine incorporates a 10-stage axial compressor and three-stage turbine. In the Model T-300J-2, almost one-third of the compressed air is bled away for external use. Over 50% more air horsepower is supplied than on gas turbine compressors currently in use by the USAF.

The new power pack is slated for use in support of the AF's Douglas B-66 twin-jet bomber. Some are supplied on a simple, self-propelled dolly, but the majority are being used on a Beech Aircraft multi-purpose vehicle which supplies air, hydraulics and electrical power and is also used to tow aircraft.

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GROUND FUEL METER

Most significant aviation development by **Revere Corp. of America** is a gravimetric ground fueling meter for truck or pit installation that accurately and directly measures and totals the weight of fuel transferred to an aircraft.

The Revere meter handles fuels ranging in density from 5.4 to 7.4 lbs/per/gal. and is rated at an accuracy of ±0.5% of total delivery. Flow range handled extends from 250 to 2,200 lbs./per/min.

Circle No. 2 on Reader Service Card.

Russian Plane Builders Stress Functionalism

Russia's aviation research and development is aimed at providing performance and serviceability at all times. Simplification is the keynote and gimmicks are ruled out. "We don't build ashtrays into fighter aircraft," is the way Russian design philosophy was summed up by a leading expert.

Despite the continuing trend toward simplification, Russian designers have not overlooked advanced ideas in developing new types of aircraft. For example, the area rule has been known to Soviet designers for a long time. It has been applied to the Suchoi delta models (AMERICAN AVIATION, Oct. 8) and also, in all probability, to the Blowlamp supersonic light jet bomber that was one of the stars of the Tushino air show this summer.

• **Another instance** of Russia's ability to keep up with the west is the Bear turboprop bomber. Many leading western aerodynamists were skeptical about the existence of the aircraft when shown sketches of the design a few years ago.

"If the Russians have succeeded in designing and flying such an aircraft," they said, "they must have come an awfully long way, because no one else has overcome flutter trouble of the swept-back wing with large turboprops." The Russians have overcome these troubles. The Bear today is in large scale production.

Another example of Russia's advance in aviation is in the powerplant field. The large axial jets which power the Tupolev Tu-104 are known to be in the 15,000-20,000-lb.-thrust bracket. No engine of comparable power is available for similar application in the west today.

Weapons Design Lags

On the other hand, weapons design and technique tend to lag in the Soviet Union. The Russians look on remote-controlled guns with suspicion. As a rule their guns have a slow rate of fire, but they seldom fail. Likewise, radar is lagging behind western standards but there is every indication that the Russians are catching up fast. High-performance tubes are still in short supply. Interestingly enough, the only German scientists still left in Russia are electronics specialists.

An indication of Russia's appreciation of the importance of electronics is the news that germanium production is to be expanded in the near future. This metal, which is very important in the production of transistors, is being produced in the Kotliakov plant at Leningrad where 14 electronic furnaces have been erected.

Although there is much talk of automation in the Soviet Union—Russia has its own Ministry of Automation in Industry—little is known of the current status of many projects. However, it has been reported that approximately 200 automatic production lines are to be introduced throughout the nation in the course of the current five-year plan.

• **Behind the advances** made by the Russian aircraft industry stand a hard corps of older Russian scientists. This "old guard" was heavily purged in the 1930s and its ranks have also been depleted by death. Notable survivors of the "old guard" are Tupolev and Yuriev. Today the brunt of design work for Russian aviation is carried out by the younger generation which gained its laurels in the Soviet era.

Top Men Overworked

Included in the younger generation are such well-known names as A. I. Mikoyan, A. S. Yakovelev, Gurevich, Polikarpov (deceased), Pavel Suchoi, Bratukhin, A. A. Mikulin, A. D. Shvetsov, and A. Kostikov (deceased). The three last named designers have concentrated on engine work. Most of the Russian aviation designers work in groups. When called upon to work alone the younger scientists do not show up well. Teamwork is, of course, universal through the Soviet Union. The personal factor is suppressed and there is a trend toward over-specialization. Men of personal initiative rarely get anywhere under this system.

The few top scientists and designers are completely overworked. Not only do they have to concentrate on work in the laboratory and drawing office, but they also have to find time to train students and to write books.

Because the Russian design teams work on an anonymous basis, there is little information on rising stars in the design field in Russia. However, the name of Zubets (designer of the Tu-104's jet engine) and Tumanski have recently been mentioned. Another prominent name in Russia is that of Professor Artakianov, a leading missile designer. It is reported that Sokholov is one of the leading members of the rising generation of aerodynamists.

• **The fount** of all technical knowledge in the Soviet Union is the Academy of the Sciences. The most important departments of the academy for aviation research are those dealing with physics and mathematics (No. 1) and technology (No. 5).

Among the leading teachers of aviation subjects are: A. F. Joffe (physics); Peter L. Kapitsa (physics); A. A. Mikulin (jet and piston aero engines); B. N. Yuriev (helicopters, aerodynamics); S. A. Christianovick (hydro- and areodynamics); L. I. Sedov (hydrodynamics); A. N. Tupolev aircraft, head of TsAGI); A. S. Yakovlev (aircraft and helicopter designer); V. Ya. Klimov (aircraft engines, corresponding member); and Y. I. Frenkel (physics).

There are numerous purely aeronautical institutes in Russia, the most important being the following:

• **Sergo Ordzhonikidze Aeronautical Institute,** located in Moscow (Volokolamskoye Chaussee 18). It can accommodate from 6,500 to 7,500 students.

• **Institute for Aeronautical-Technology,** located in Moscow (Pl. Borby 31-33). Headed by Prof. N. V. Indzemtse. Specializes in aircraft production techniques. Some 3,500 students.

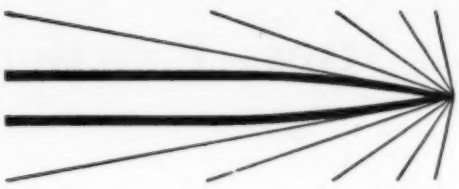
• **Aeronautical Institute of Kharkov** (Ul. Sumskaya 18-20). Specializes in airframes and engines. It was formerly at Kharkov (Pomerki 27) and was called Ossoviakhim (the predecessor of the present DOSAAF pre-military training organization which has a large aeronautical branch).

• **Aeronautical Institute of Kuibyshev** (Ul Cooperativnaya 110). This institute, small in comparison to those at Moscow, gained in importance after the war, because of the large new production centers for aircraft and jet engines at Kuibyshev. It trains students in aircraft construction, jet techniques and rocket and turboprop jet engines. The works at Kuibyshev were among the first that switched production from piston to jet engines. Approximately 2,000 students.

• **Aeronautical Institute of Kazan** (Karl Marxe Ul. 10). Important because it is in the aircraft plant in the town of Kazan. This builds four-engined aircraft. Also important for turboprop development.

• **Aeronautical Institute for Aircraft Equipment,** located in Leningrad (Moskovskoye Chaussee 74). This is the largest institute of its kind in the USSR.

• **Aeronautical Institute of Gorky.**



MISSILE ENGINEERS

Many new positions are being created at Northrop Aircraft for missile engineers in a wide range of activity: control, guidance, servo, computers, recording, optical, reliability, electro-mechanical, telemetering and electronics. There's an interesting position for you, at your own experience level, with attractive remuneration and steady advancement, in one of the following groups:

GUIDANCE AND CONTROLS, encompassing research and development of advance automatic guidance and flight control systems for both missiles and piloted aircraft. Specific areas of development include: radio and radar systems, flight control systems, inertial guidance systems, instrument servo systems, digital computer and magnetic tape recording systems, airborne analogue computer systems, optical and mechanical systems, and systems test and analyzer equipment.

FLIGHT TEST ENGINEERING SECTION, which plans the missile test programs and establishes test data requirements in support of the programs. The data requirements are predicated on the test information required by the engineering analytical and design groups to develop and demonstrate the final missile design, and are the basis from which instrumentation requirements are formulated.

The analysis work performed consists of aerodynamic, missile systems, dynamics, flight control, propulsion and guidance evaluation. The Flight Test Engineering Section is also responsible for the field test program of the ground support equipment required for the missile.

FLIGHT TEST INSTRUMENTATION SECTION, which includes a Systems Engineering Group responsible for the system design concept; a Development Laboratory where electronic and electro-mechanical systems and components are developed; an Instrumentation Design Group for the detail design of test instrumentation components and systems; a Mechanic Laboratory where the instrumentation hardware is fabricated; and a Calibration and Test Group where the various instrumentation items and systems are calibrated and tested.

For 17 years Northrop Aircraft has pioneered in missile research and development. As a member of this forefront organization in this growing field, new opportunities for full expression of your initiative and ability will always be yours at Northrop.

If you qualify for any of these attractive positions, we invite you to contact the Manager of Engineering Industrial Relations, Northrop Aircraft, Inc., telephone ORegon 8-9111, Extension 1893, or write to: 1015 East Broadway, Department 4600-N, Hawthorne, California.

NORTHROP

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Producers of Scorpion F-89 Interceptors and Snark SM-62 Intercontinental Missiles

Importance and scope of work unknown.

• **Institute for Aerial Photography and Geodetics** is located at Novosibirsk (Ul. Krylove 24). It has been suggested that there is also an institute for rockets at Novosibirsk.

• **Institute for Aerial Photography and Cartography,** located in Moscow. Headed by Prof. P. T. Stepanov.

• **Aeronautical Institute of Tashkent** (Ul. Kuibysheva 8.)

• **Aeronautical Institute of Ufa** (Ul. Lenina 61). Important for aircraft engine studies because of the large engine plant near the town of Ufa. Approximately 1,000 students.

Training in the above institutions usually takes five and a half years. Courses are tough and standard of work is very high. Some part of the course is devoted to political doctrines and students wear uniforms both on and off duty. Equipment at these institutes is generally good, but up-to-date books and other reference material is scarce.

Many books exist on aviation subjects but they are usually out of print. The Russians do not make available to the aviation institutes, as far as can be determined, the large amount of technical information which comes in to the technical intelligence center in Moscow from some 13,000 correspondents all over the world. This mass of information is collated with the aid of Hollerith machines.

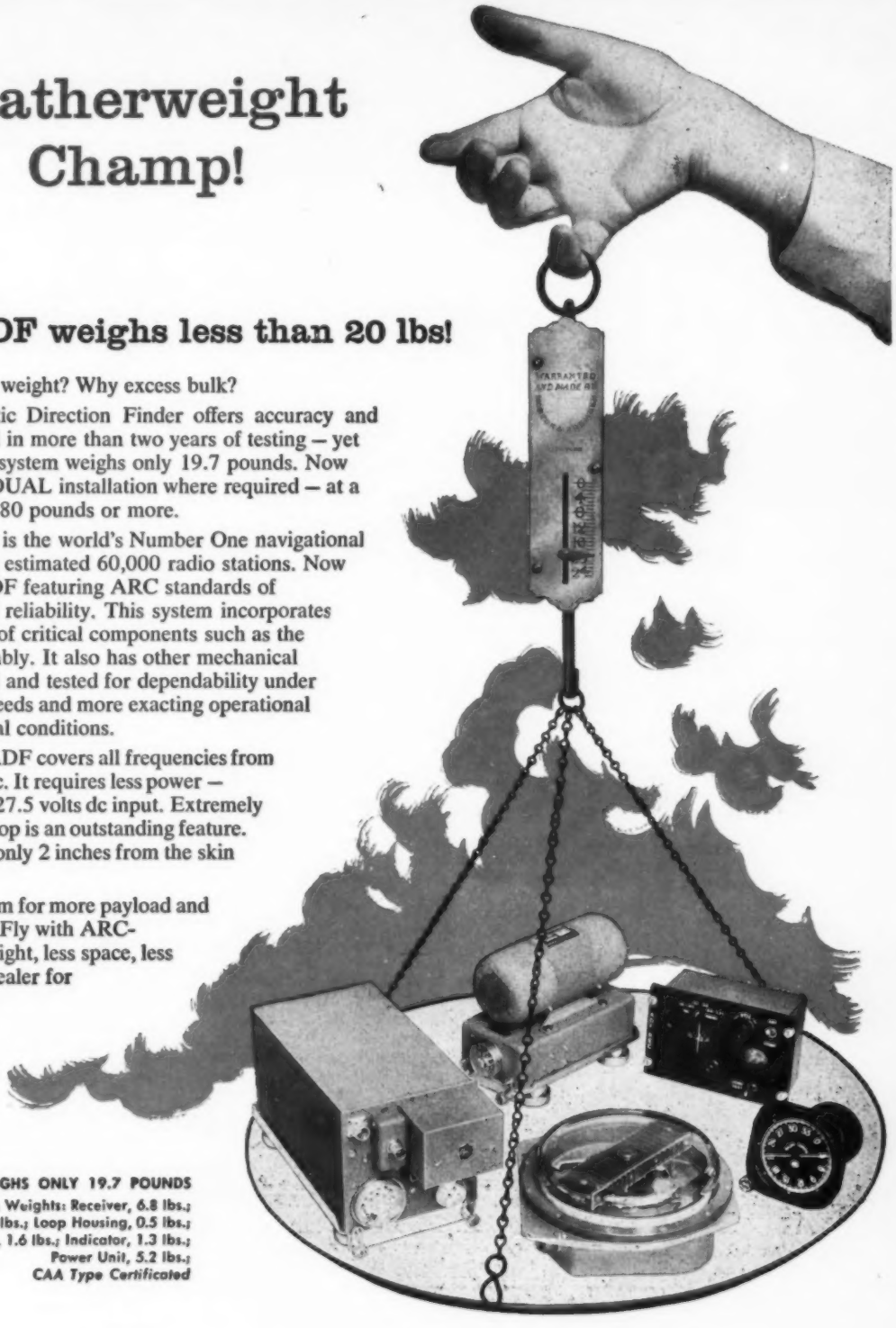
All the research and test institutes of the aircraft industry are under the direct supervision of the Ministry of Aircraft Production. The most important is the famous TsAGI, which was formed in Moscow in 1923. It has several branches throughout the Soviet Union and has been headed by A. N. Tupolev for many years. Most of the Russian aircraft developed in the past three decades originated at TsAGI. The flight test department of TsAGI is located at Ramenskoye airfield near Moscow.

The central institute for aircraft engines, the Baranov institute, is known as TsIAM. It is located in Moscow but has branches in various other cities. There are three other central institutes connected with aviation: VIAM, which is responsible for material testing; the institute for aircraft equipment; and the institute for aircraft fuels and lubricants.

Mention should also be made of the so-called Central Design Bureau (TsKB), that is directly responsible to the Ministry of Aircraft Production. This body approves all aircraft design work which may have been carried out at various pilot aircraft plants as well as designs originated by TsAGI. ◆◆◆

8-A-58

Featherweight Champ!



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Why carry dead weight? Why excess bulk?

This Automatic Direction Finder offers accuracy and reliability proved in more than two years of testing – yet the entire 5-unit system weighs only 19.7 pounds. Now you can have a DUAL installation where required – at a weight saving of 80 pounds or more.

The ADF still is the world's Number One navigational aid, usable on an estimated 60,000 radio stations. Now you can have ADF featuring ARC standards of performance and reliability. This system incorporates hermetic sealing of critical components such as the entire loop assembly. It also has other mechanical features designed and tested for dependability under today's higher speeds and more exacting operational and environmental conditions.

The Type 21 ADF covers all frequencies from 190 kc to 1750 kc. It requires less power – only 2.8 amps at 27.5 volts dc input. Extremely low drag of the loop is an outstanding feature. Housing extends only 2 inches from the skin of the aircraft.

Now make room for more payload and other equipment. Fly with ARC-reliability, less weight, less space, less drag. Ask your dealer for complete details.

TYPE 21 ADF WEIGHS ONLY 19.7 POUNDS
Component Units Weights: Receiver, 6.8 lbs.; Loop, 4.3 lbs.; Loop Housing, 0.5 lbs.; Control Unit, 1.6 lbs.; Indicator, 1.3 lbs.; Power Unit, 5.2 lbs.;
CAA Type Certificated

Dependable Airborne Electronic Equipment Since 1928

Aircraft Radio Corporation **BOONTON, NEW JERSEY**

Omni/ILS Receivers • Course Directors • UHF and VHF Receivers and Transmitters LF Receivers and Loop Direction Finders • 10-Channel Isolation Amplifiers • 8-Watt Audio Amplifiers • Interphone Amplifiers • Omnirange Signal Generators and Standard Course Checkers • 900-2100 Mc Signal Generators

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People

MANUFACTURING

Bob Rahn appointed senior testing representative for Douglas' El Segundo division; **Tom Kilfariff** succeeds him as project test pilot on F5D.

John C. Virden elected president of Eaton Manufacturing Co.; **Howard J. McGinn** continues as board chairman.

Clifford W. Brown appointed president of Narmco Resins and Coatings Co.

KENDALL

Jules Kendall heads the new research and development division at Greer Hydraulics, Inc.

New staff appointments at Beech Aircraft Corp.: **J. E. Isaacs**, mgr. industrial relations; **George W. Hostetter**, mgr. contract administration; **R. H. Owen**, mgr. mfg. engineering; **W. A. Powers**, mgr. mfg. control; **R. Warren Fisher**, mgr. budget control; **W. E. LaVelle**, mgr. Plant III in Wichita. Promoted to chief project engineers: **H. D. Barnett**, commercial aircraft; **Robert P. Aylward**, military aircraft; **William A. Day**, propellers and subcontracts; **A. L. Clark**, external stores and research; **James W. Massey**, ground support equipment.

Joseph W. Rice appointed mgr. of ACF Industries, Inc.'s public relations department.

Chedo P. Graham promoted to chief engineer of the Aro Equipment Corp.

Dr. Harvard L. Hull, president of Farnsworth Electronics Co. until Oct. 1, joins Litton Industries as vice president.

Richard P. Frazee appointed Washington representative for Reaction Motors, Inc.

PIORE

Dr. Emanuel R. Piore has joined International Business Machines Corp. as director of research.

Frederick A. Fielder appointed gen. sales mgr. for the Loewy - Hydropress division of Baldwin - Lima - Hamilton Corp.

William B. Haylon joins McDonnell Aircraft Corp. Nov. 1 as mgr. of public relations.

Henry J. Hamm, formerly sales mgr. of LearCal division of Lear, Inc., resigned to become sales manager consultant.

Leonard C. Mallet promoted to gen. mgr. of Pratt & Whitney Aircraft's Connecticut operations; **Charles T. Roelke** to gen. mgr. of Florida operations; Newton V. Turney to divisional controller of Florida operations.

Adm. John H. Cassady (USN, ret.) elected exec. vp of Flight Safety Foundation, Inc.

Alexander H. d'Arcambal retires as president and gen. mgr. of Pratt & Whitney Co., Inc. Nov. 1; **Edward P. Gillane**, exec. vp succeeds him.

William G. Mays appointed director of sales and service for Meletron Corp.

Robert E. Fitzwilson named asst. director of quality control at Lockheed Aircraft's Georgia division; **Clarence H. Roha** appointed mgr. of purchasing division.

Edwin D. Maxfield named commercial div. mgr. of the aviation dept. of Shell Oil Co.'s New York office.

Don P. Kingsley appointed asst. to the president of Gladden Products Corp.

Albert W. Gruer, Jr. named director of marketing research and **M. F. Mellinger** export mgr. of Cessna Aircraft Co.

Dr. Frank G. Miller heads the engineering laboratory of Hughes Aircraft Co.'s guided missile laboratories.

Brian Sparks named gen. mgr. of Clary Corp.'s aircraft division while continuing as chief engineer.

J. P. Donald Garges appointed sales mgr. of the Wright Aeronautical Division, Curtiss-Wright Corp.

Charles Knight named gen. mgr. of Air Associates' facsimile equipment division.

Walt Edwards appointed chief systems engineer and **Ed Klein** project engineer for the National Cash Register Co.'s electronics division.

W. W. Gilmore elected a vp of Minneapolis-Honeywell Regulator Co.

Erich Schatzki elected president and board member of Liberty Products Corp.

George R. Harris appointed mgr. of sales for General Electric's light military electronic equipment dept. **Dr. Richard C. Raymond** will head a new defense electronics planning operation to be established by GE at Santa Barbara, Calif.

Richard C. Hess appointed sales mgr. for the instrument division of Federal Telephone and Radio Co.

Don J. Murphy, now director of mfg. of Lockheed's missile systems division, will be director of the Van Nuys plant in charge of all operations after the division's head office moves to San Francisco Bay area.

H. T. Dietrich will be in charge of Kaman Aircraft Corp.'s new Washington office.

James P. Malmstrom appointed vp of United Aircraft Products, Inc.

George S. Kariotis named gen. sales mgr. for Microwave Associates, Inc.

Robert S. Miller appointed works mgr. of Servomechanisms, Inc.'s products plant at Hawthorne, Calif.

Holley B. Dickinson appointed asst. to the president, Consolidated Electrodynamics Corp.

J. S. Morison named chief, missiles computing section, and **O. E. Nemitz**, chief of missiles data reduction section, Douglas Aircraft Co.

Richard H. Graham becomes staff scientist for nuclear engineering at Lockheed's missile systems division; **Everett E. Christensen** appointed asst. test division engineer.

Bruce H. Atwater appointed sales mgr. for Pastushin Aviation Corp.

AIRLINE

Herbert W. Seagrim succeeds **William F. English** as vp-operations for Trans-Canada Air Lines; **J. Norman Donnelly** appointed operations mgr. for TCA's western region.

C. M. Doolittle named mgr. for Braniff Airways' activities in Argentina, Uruguay, Paraguay and Chile.

Leonard P. Cornwall appointed cargo sales mgr.—U.S. for Pan American World Airways. **Lloyd M. Wilson** named traffic mgr. for PAA's Atlantic Division.

Francis A. Bickel appointed asst. treasurer of United Air Lines.

Andrew A. Burns named gen. sales mgr. for North America for SABENA Belgian World Airlines.

FARRELL

Edward L. Farrell, Jr. elected vp of Pan American-Grace Airways.

Robert S. Grant elected asst. vp-traffic of National Airlines.

James C. Dixon promoted to post of traffic mgr. of Central Airlines.

James E. McLarney succeeds **Karl Hollman** as agency and interline mgr. of Lufthansa German Airlines for North America.

GOVERNMENT

Ernest H. Hensley, deputy regional administrator of the First Region of the CAA in New York, becomes deputy administrator of the Fourth Region in Los Angeles; **Allen E. Horning** named asst. administrator of the Fourth Region.

Dr. R. Paul Harrington, head of aeronautical engineering at Rensselaer Polytechnic Institute, will head the new Training Center for Experimental Aerodynamics sponsored by NATO at Rhodes Ste. Genese, Belgium.

J. Paul Walsh named deputy director of the Navy's earth satellite program.

HONOR ROLL

(For 25 year's or more service in the industry)

Max Stuart-Shaw, Aer Lingus Irish Air Lines. Asst. gen. mgr. Dublin.

HONORS

John Eichner, vp-traffic and sales of Trans-Texas Airways, elected chairman of Traffic Committee Air Express at the Air Cargo Advisory Board convention.

Miles O'Brien of TWA elected president of the Airline Traffic Association of Washington.

Eugene Ertel, chef, Chicago flight kitchen of United Air Lines, elected president of the American Culinary Federation.

Richard T. Whitcomb, aeronautical research scientist of the NACA Langley Aeronautical Laboratory, awarded NACA's first Distinguished Service Medal for his "discovery and experimental verification of the Area Rule" which provided a useful means of increasing the speed of airplanes in supersonic flight.

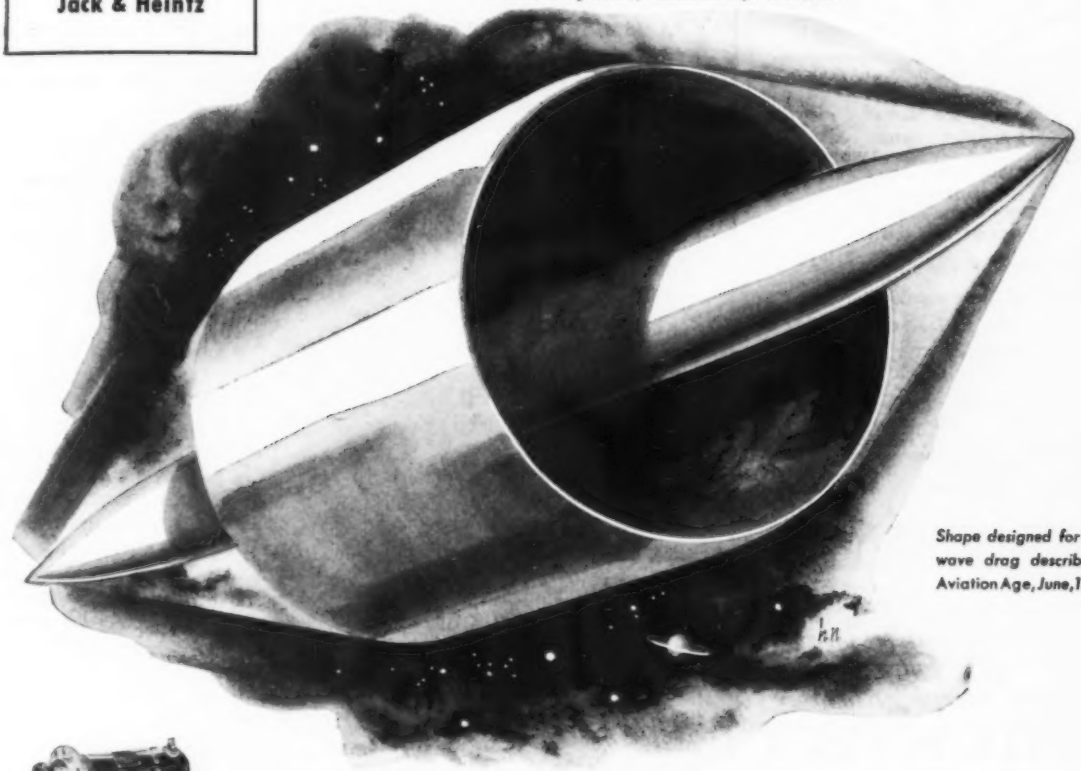
Warren Lee Pierson, chairman of the Board of Trans World Airlines, awarded the Commander's Cross of the Order of Merit of the Federal Republic of Germany, in recognition of his services to civil aviation in Germany and strengthening friendly ties between the United States and the Federal Republic.

Morehead Patterson, president, American Machine and Foundry Co., elected chairman of the Nuclear Standards Board of the American Standards Assn.

Your tomorrow's electric system waits today at Jack & Heintz

ENVIRONMENT-FREE GENERATORS

J&H oil-cooled machines deliver full-rated output independent of aircraft speeds, ambients, altitudes

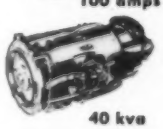


Shape designed for zero wave drag described in Aviation Age, *June, 1956.*

2.5 kw

12.3 kw

100 amps



40 kva

20 kva

17 kva

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- deliver full-rated power regardless of aircraft speeds, ambients, or altitudes
- are smaller than any comparable air-cooled units
- enable lighter and simpler installations
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Scheduled for service on advanced aircraft, these J&H generators promise to be the ultimate approach to aircraft electric power.

"Standardized" Approach to Each Advanced Electric System

Regardless of the flight plateau you are sighting, the J&H oil-cooled generators, with the proper heat sink, offer an immediate solution to your electric power needs. This frees you of long lead times to develop new generators. Each advance in flight conditions is met through adjustment of the heat sink.

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Volts	d-c 3 outputs	a-c, d-c 3 outputs	30	120/208	120/208	120/208
Speed (rpm)	12,000	12,000	8,000	6,000	8,000	12,000
Phase (cps)	—	—	—	3	3	3
Frequency (cps)	—	1,600 400	—	400	400	400
Power Factor (min)	—	—	—	.75	.75	.75
Weight (lb)	30	70	36¼	165*	100*	50
Length (in.)	12.71	14.3	10.57	27.25*	26.0*	12.85
Diameter (in.)	4.5	7.75	6.5	13.0*	9.5*	7.5

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West Coast Talk . . . By Fred S. Hunter

• AF blocked proposal to get facts of life on jet transports five years ago.

CAA'S B-57 PROGRAM to pick up a few of the jet facts of life before the airlines start taking to the airways with turbine equipment reminds one of the time E. M. (Jock) Ellingson, now an assistant to Cliff Garrett at AiResearch Manufacturing, tried to sell the Air Force on a similar idea more than five years ago.

Hunter

Ellingson was C.O. of the Southern California Reserve Division, a special MATS outfit that had been organized in Los Angeles following World War II, with Lt. Gen. Harold George, war-time commander of the Army Air Transport Command, as sponsor.

Ellingson proposed that the Air Force authorize his group to set up a daily schedule between Los Angeles and San Francisco with four-engine B-45s for an actual jet service test in simulated transport operation. Jock's outfit included 35 crews composed mainly of professional pilots flying either for the airlines or the aircraft factories, and was quite capable of doing the job. He had learned of three B-45s which could have been made available and Dutch Kindelberger, chairman of North American Aviation, readily agreed to provide service support for the aircraft.

This is the type of information Ellingson proposed to obtain in detail: 1) basic requirements in time, manpower and costs of operation, maintenance and overhaul of jet engines, stable cruising power conditions; 2) fuel consumption characteristics of powerplants in transport-type operation; 3) answers to navigation and traffic control problems; 4) actual operation in upper air conditions; 5) ground operation problems, such as possible exhaust damage, necessary spacing between aircraft in taxiing, etc.

Airport authorities in Los Angeles and San Francisco were enthusiastic. So was the regional CAA office. But not the Air Force. It said: "No soap." Now, in 1956, the CAA starts out to run down a part of the answers Ellingson and his associates wanted to go after in 1951. Quite a few of today's uncertainties about jet transports might already have been disposed of if the Air Force had given the Ellingson proposal the green light.

• •

The unfortunate Bell X-2 crash at Edwards AFB has touched off another round of speculation on North American Aviation's X-15, since this aircraft, apparently, is next in line among these probing vehicles for the investigation of space. A lot of guessing has taken place regarding the design objectives of the X-15. Not long ago, San Francisco papers quoted George Smith, the North American test pilot, as saying his company was working on a manned aircraft to reach an altitude of 180 miles. But, this, as it turned out, wasn't the information direct from the feed-box it seemed. Smith was just repeating something he had seen in print. The 180-mile number is higher than any we had previously heard, although we've heard some pretty high ones. If they're anywhere near correct, we'd guess North American's X-15 would emerge as a progressive series of planes and go up in steps, as the Bell X-1, X-1A, X-2 series did. More guessing—first model in the series ready in about a year.

• •

Transition to the supersonic is taking place pretty fast in the Air Force, with more than 600 North American F-100s in the field and Convair coming along with F-102s . . . Lou Goss, western manager of properties for TWA, and Tommy Tucker, chief engineer for the Los Angeles International Airport, a couple of buddies, become eligible for retirement on the same day, December 31, 1959, and that is just one day before the new LA terminal building, on which both will do a lot of work over the next three years, is scheduled for completion . . . Burns Aero Seat has developed a knee-action berth support for TWA's new Lockheed 1649A Super Stars to make life easier for hostesses.

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Industry News Digest

NACA Studies Jet Flap as Means Of Reducing Runway Requirements

Along with its program to step up the speeds of aircraft and missiles to Mach 5 and beyond, the National Advisory Committee for Aeronautics has disclosed it is investigating the jet flap as a device for reducing flight speed, and hence the runway requirements, of large jet transports.

At the recent triennial inspection of the Langley facilities, two versions of the jet flap were demonstrated:

• A system permitting the deflection of the exhaust of conventional pod-mounted jet engines through a slotted flap at the trailing edge of each wing.

• A system involving the use of small jet engines mounted within the wings themselves, which eject all of their exhaust through a slot in the trailing edge of each wing.

• **Purpose of** the jet flap arrangement is to form a huge artificial wing flap by means of the jet exhaust itself. While some lift is provided by the exhaust blast, most of the added lift results from the entrainment of the airflow over the top of the wing. This super-circulation provides a surprising amount of lift, according to NACA.

Analytical studies indicate that a jet flap could trim takeoff distance from 8,500 feet to 4,500 feet for a large jet transport, NACA said. It could reduce landing distance from 7,000 feet to 3,700 feet, minimum takeoff speed from 150 to 115 mph, and landing speed from 115 mph to 80 mph.

The Langley inspection made it clear, however, that the bulk of the government's aeronautical research effort is directed at developing: 1) aircraft fast enough to shrink the globe so that any two points will be within a comfortable day's journey, and 2) ballistic missiles that can reach their targets despite the terrific temperatures generated by aerodynamic heating.

• **So rapidly** has manned flight progressed into supersonic flight regimes that NACA has been sorely taxed to provide detailed aeronautical data from its present facilities.

"Not only are these demands very great for the lower supersonic speeds up to . . . Mach 2.5," said F. L. Thompson, assistant director of Langley, "but aircraft designs contemplated for higher and higher speeds are extending these demands to the upper range of supersonic speeds and well into the hypersonic range above a Mach Number of about 5."

Among the highlights of the Langley research program:

• Development of a four-stage rocket assembly utilizing two Nike boosters and two Thiokol rockets which achieved Mach 10.4 and an estimated altitude of 200 miles when fired from Wallops Island, Va. over the Atlantic. Purpose of the program is to secure detailed data on missile warhead reentry problems.

• Use of a quartz tube heat radiator which can provide rapid, unsymmetrical heat changes on aircraft skins and other structures which simulate the uneven heating rate encountered by aircraft maneuvering at high speeds.

• Two windtunnels with four-foot test sections capable of simulating speeds ranging from Mach 1.5 to 5, plus a third tunnel with an 8.75-by-6-foot test section now under construction that will permit simulated speeds of Mach 3 when completed.

• Use of ceramic heat exchanger to boost the temperature of high-speed air jets in a small tunnel to a level encountered at Mach 5 and above—more than 4,000 degrees F.

• Landing gear test facility utilizing a water catapult capable of accelerating a carriage to 150 mph in 400 feet and exerting a load of 20,000 pounds on a single landing gear.

Navy Unveils Sidewinder Missile

Newest of Navy's operational missiles is air-to-air Sidewinder shown mounted under wings of Grumman F9F Cougar. Sidewinder measures 8-to-9 ft. long, is faster and has greater range than Sperry Sparrow. It was developed at Naval Ordnance Test Station, China Lake, Calif., and is being built by Philco (Philadelphia) and General Electric Co. (Utica, N.Y.).

USAF Weighs Drive For Chemical Bomber

The USAF Air Council was expected to get down to business this month on the WS-110A chemical-fueled bomber as well as a new interceptor, according to talk in aircraft industry circles.

The big bomber development project has been stewing for several months, awaiting an Air Force decision on the magnitude of support it is to receive. The program has reached the stage where further development by Boeing Airplane Co. and North American Aviation, Inc., will require a big cash payout from the Air Force.

The WS-110A is designed as a replacement for the B-52 when that reaches obsolescence about 1962. Using "exotic" fuels, it will have greater range than the B-52, supersonic speed and a great altitude capability.

An Air Force decision on whether to go ahead with a new interceptor also appears imminent. The USAF has sought to encourage the industry to come up with design proposals for a medium-range interceptor ever since last spring when it cancelled its Phase I competition for a long-range interceptor.

Link to Build F-106A Simulators

Air Force has awarded Link Aviation, Inc. a contract in excess of $3 million to produce an undisclosed number of flight simulators for Convair F-106A supersonic delta interceptors. Prototype model is scheduled for delivery in early 1958.

The F-106A is a Pratt & Whitney J75-powered version of the Convair F-102 for which Link also produced simulators. Company also is developing simulators for the Navy's Grumman F11F, Chance Vought F8U and Douglas F5D.

CAA to Use Airborne Computers For Checking U.S. Navigation Facilities

Airborne computer-equipped Convair 440s will speed up flight checking of federal air navigation facilities to 30 days per facility instead of the 120 days now required. Computers are part of a new system devised by Arthur E. Jenks, CAA flight inspection chief, and developed by his staff.

The system calls for dividing the country into East-West and North-South grid lines 100 miles apart, enabling the flight check aircraft to check all facilities within 200 miles. This will enable elimination of the present orbiting practice which calls for the aircraft to fly concentric circles around each radio range.

The signals received under the new system will be fed into the computers and recorded on tape. Inaccuracies then will be picked up by an "electronic brain" system to be installed at CAA's Oklahoma City Aeronautical Center. As inaccuracies are detected, service crews will be immediately dispatched.

Inauguration of the new system is contingent on delivery of the Convairs, expected in late 1957 and early 1958, and development of the airborne computers. CAA has discussed the projected development with about 30 engineering and electronic firms.

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Military Spending To Rise, Says Wilson

Overall military spending next year will increase "something like" 4% to 6%, but "certainly less" than 10%, according to Defense Secretary Charles Wilson. This would mean a boost of from $1.5 billion to $2.2 billion over this year's spending rate.

Wilson said he had no plan under study to produce more B-52s faster with the $900 million in extra USAF funds voted by Congress. However, the money might reduce his appropriation request for next year, he said, adding: "It is bound to have some effect. Congress just gave us credit in the bank quicker than we thought we needed it."

He admitted the possibility of an armed forces manpower cut of 100,000 or more next year, stating that final decision on this and on the budget should be ready by Dec. 15.

At a press conference, Wilson declined to elaborate on what he has previously said about a possible cut in the planned size of USAF. The number of wings is not "sacrosanct" and is under continuous study, he said. He also (1) refused to say whether the U.S. has fired a test rocket as far as 3,000 miles, (2) would not answer directly whether U.S. military planes would be allowed to break the British-held speed record of 1,132 mph.

Lockheed 1649A Makes First Flight

Lockheed's Model 1649A Super Star Constellation successfully completed its first flight on October 11. Flown by Roy Wimmer with Herman Salmon as copilot, the aircraft remained aloft for 50 minutes.

First production 1649A will now enter a six-month certification test program leading up to initial delivery to Trans World Airlines in April. Deliveries to Air France will start in June, with those to Lufthansa, Linee Aeree Italiane and Varig Brazilian airline to follow.

CAA Defers Decision On S-58 Crew Needs

Civil Aeronautics Administration has delayed until at least November 10 a final decision on whether one or two pilots will be required in New York Airways' Sikorsky S-58 helicopters.

CAA operations and airworthiness chief W. B. Davis has deferred action until that time to give the carrier opportunity to gain additional operating experience. Davis said that serious differences of opinion and conflicting reports have been given by management and pilots on the safety aspects of one-crew operation.

CAA study of the issue stemmed from a demand by Air Line Pilots Assn. president C. N. Sayen that a two-man crew be required in the 12-passenger helicopters.

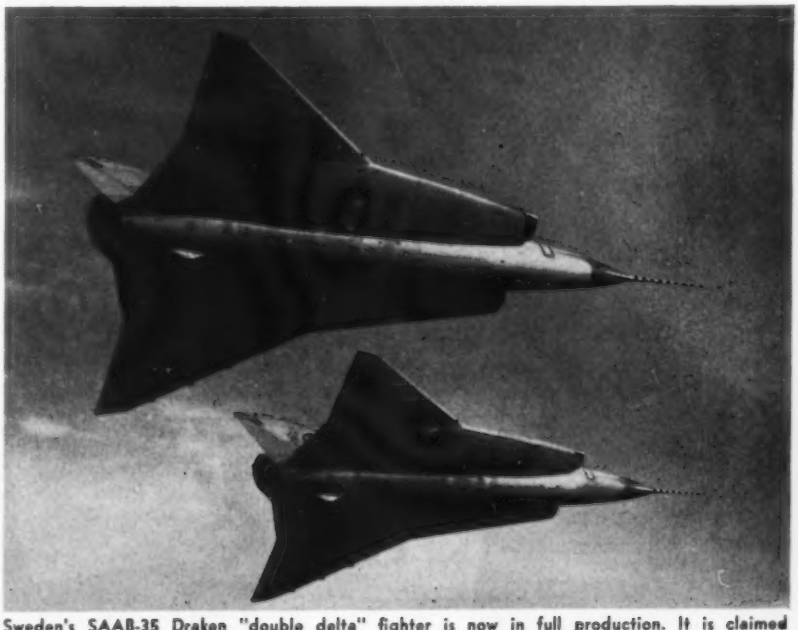
Pilot Urges Action On Collision Problem

United Air Lines captain V. A. LeRoy has urged airline pilots as a group to take the air traffic control collision problem into their own hands and offered a three-point program "to do something about it."

In a signed article in the current issue of the Air Line Pilots Assn. publication *Air Line Pilot*, LeRoy says it is evident that the airlines and government have been "ducking" the responsibility that pilots cannot duck. He urges that all pilots immediately in-

(*Continued on page* 162)

'Double-delta' Swedish Fighter in Production



Sweden's SAAB-35 Draken "double delta" fighter is now in full production. It is claimed to be the fastest aircraft in full production status in Europe.

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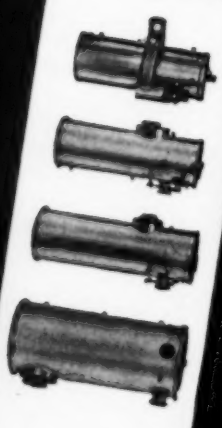

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Dry lift. Due to ability to pump air, the pump will re-prime.
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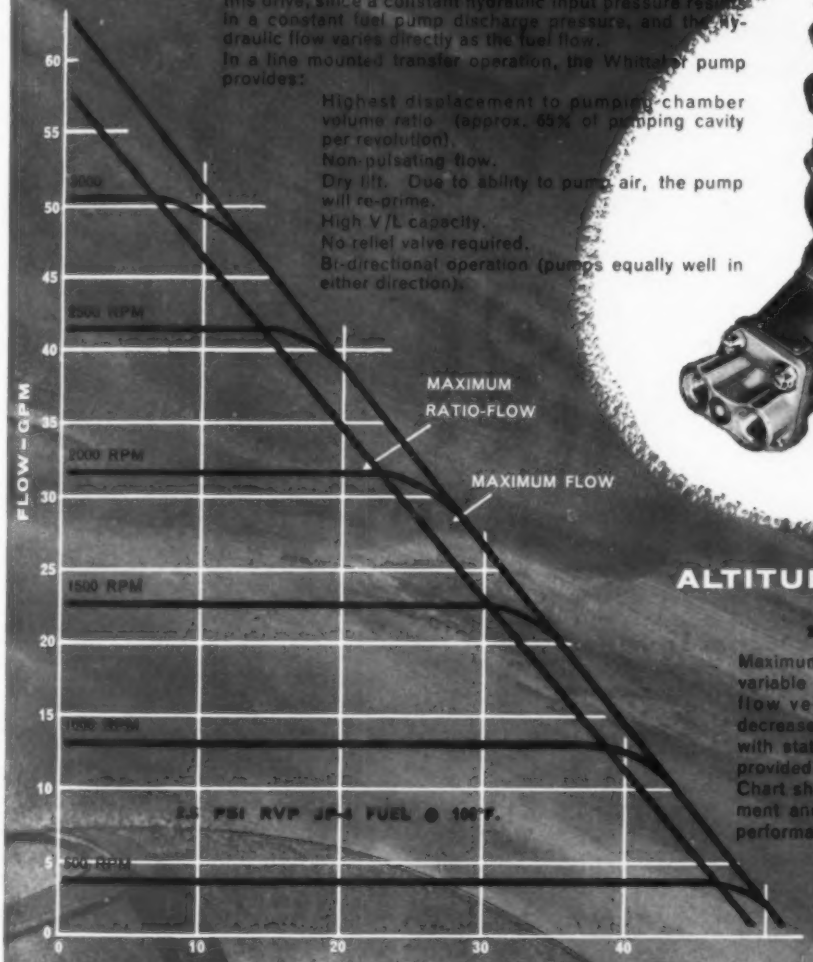

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Industry News Digest

(*Continued from page* 159)

stitute these remedial measures to combat the collision threat:

- File IFR plans for all flights above 5,000 ft. altitude.
- Accept no VFR or "on top" restrictions for above 5,000 ft. or while operating at speeds in excess of 160 knots at any altitude.
- Refrain from "off-airways" flying, except to avoid thunderstorms, until CAA can provide traffic separation from other airline aircraft on such routes.

The UAL pilot concedes that such measures would be "stopgap" in nature and leave a lot to be desired. "Operations would be curtailed," he added, ". . . possibly some of us might lose our runs. Management would probably not like it, but again they might if all operated under the same conditions."

EAL Orders More 440s; To Get First Electras

Eastern Air Lines, in two separate equipment planning moves, has increased its order for Convair 440s from 15 to 21 and decided *not* to adopt the "living room" look in its Lockheed Electra turboprops.

The follow-on 440 order came in August when EAL learned that the six aircraft could be delivered between March and July, 1957, giving it much-needed equipment for early use on routes acquired from Colonial Airlines.

Eastern's decision to stay with a two-and-two seating arrangement in its Electras will make it the first airline to take delivery of the Lockheed turboprops.

Lockheed originally scheduled simultaneous delivery of first aircraft to both EAL and American, but the latter agreed to a three-month delay in adopting the revised 76-passenger "living room" layout. As a result, Eastern probably will receive five or six Electras before American takes first delivery.

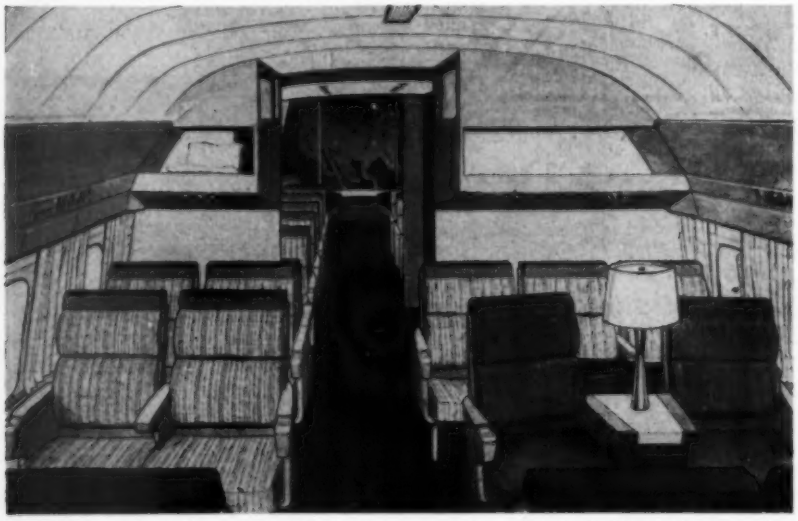
Malfunctioning Switches Caused Capital Mishap

Malfunctioning propeller control switches probably caused the nonfatal accident of a Capital Airlines Viscount during approach to Chicago's Midway Airport on Feb. 20, CAB said in its final report on the accident.

During final approach, props moved to the ground fine pitch range, resulting in abrupt loss of lift, CAB found. It added that at least two prop control microswitches apparently were malfunctioning when the Viscount left Detroit. These energized a 21-degree prop pitch lock solenoid and warning light which went unobserved by the crew.

Consequently, CAB said, an emergency switch, which is provided to prevent props going into ground fine in flight, was not actuated. Since no instructions had been provided the crew of the consequences, the throttles were advanced, causing the props to seek the lowest possible blade angle. Resultant loss of lift dropped the plane to the ground, causing substantial damage.

New Look For AA Electras



New "living room" theme adopted by American Airlines for its Lockheed Electra turboprops features three compartments with informal seating, tables and lamps. In all, AA layout will provide seven separate cabin sections, two with standard two-and-two seating, three "living rooms," a section with club type seats and the aft lounge. Seating capacity is increased from 66 to 76.

Fairchild Lists Orders, Options for F-27s

First quarterly report of Fairchild Engine and Airplane Corp. (to Sept. 30) shows the Hagerstown, Md. firm has received firm orders for at least 27 F-27 Friendship turboprop transports plus options for another 25.

However, the company notes that these do not represent *all* F-27 sales—some others received from various corporations have not been disclosed.

Here's how Fairchild tabulates announced orders for the F-27:

Airline	No. of Planes Firm	Option	Date of Order	Delivery Year
Mackey	2	2	1-5-56	1957
West Coast	4	4	12-2-55	1957
Piedmont	12	12	1-24-56	1957
Frontier	4	2	4-12-56	1958
Bonanza	3	3	5-11-56	1958
Quebecair	2	2	9-25-56	1958

CAB Proposes Rule On Emergency Exits

Civil Aeronautics Board's Bureau of Safety Regulation has proposed a rule that will spell out cabin emergency exit requirements well into the future—until cabin capacities exceed 239 passengers.

Board's staff has set November 9 as deadline for comment on its suggested requirements. They consider four types of exits with these minimum dimensions in width and height: Type I—24″ x 48″; Type II—20″ x 44″; Type III—20″ x 36″; and Type IV—19″ x 26″.

Number of various types by passenger capacity would be:

	Type I	Type II	Type III	Type IV
1 to 10 incl.	—	—	—	—
20 to 39	—	1	—	1
40 to 59	1	—	—	1
60 to 79	1	—	—	2
80 to 99	1	—	1	1
100 to 119	1	1	—	2
120 to 139	2	—	—	2
140 to 159	2	—	1	2
160 to 179	2	1	—	2
180 to 199	2	2	—	—
200 to 219	3	1	—	—
220 to 239	4	—	—	—

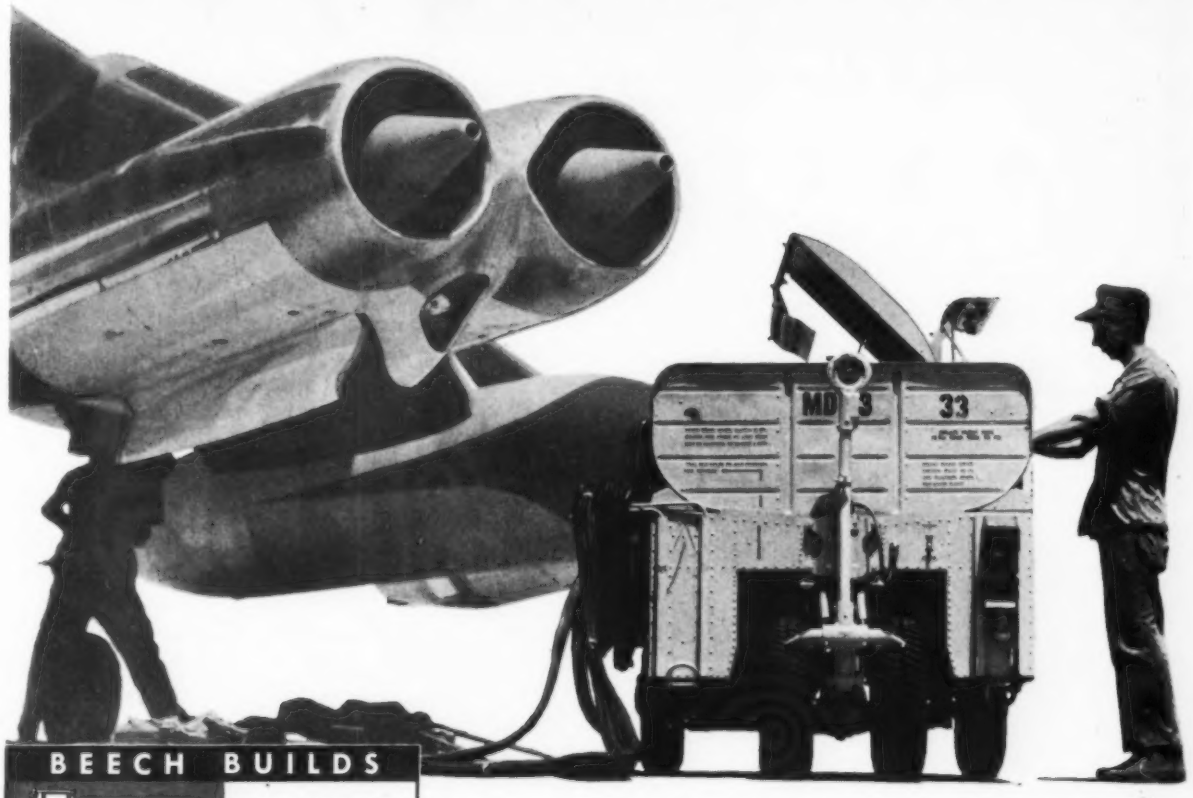
ICAO Names Jet Age Navigation Task Force

A seven-man International Civil Air Organization jet age navigation task force, headed by chairman Dr. Edward P. Warner, has been named and awaits only ICAO Council approval.

Members include Col. Luis de Azcarraga, Spain; Col. Helio Costa, Brazil; A. P. Dekker, Netherlands; Jerome Lederer, Flight Safety Foundation,

(*Continued on page* 166)

CAPABILITIES . . . Manpower, Tools and Experience



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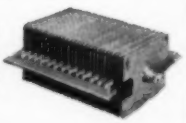

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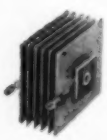

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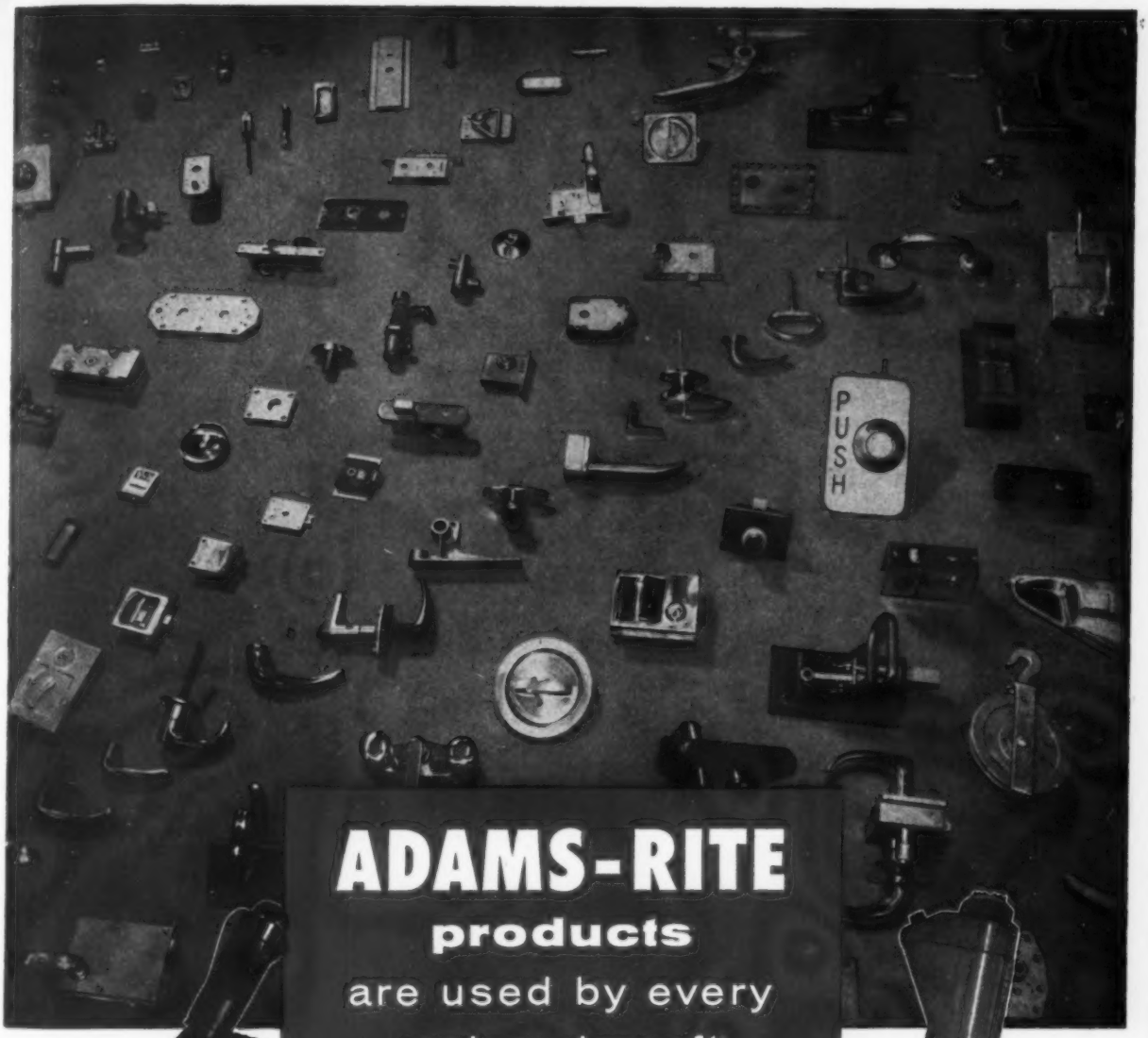

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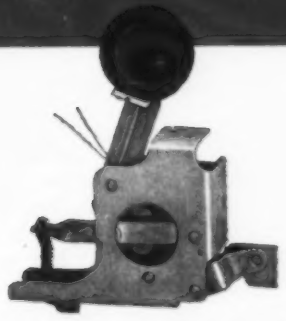

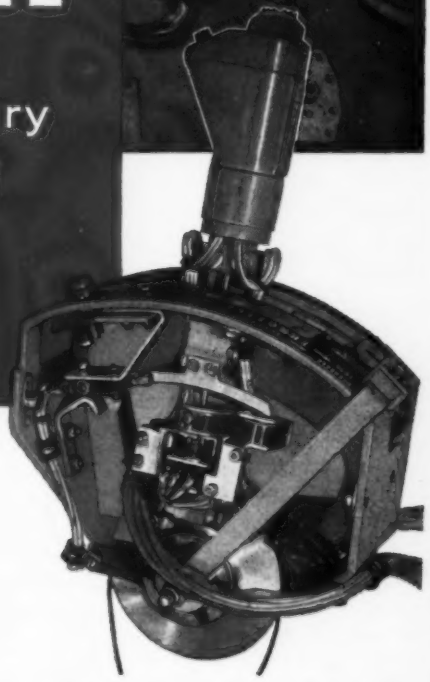

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Circle No. 154 on Reader Service Card.

Industry News Digest

(*Continued from page* 162)

U.S.; Rene Lemaire, France; and Air Vice-Marshal Sir Victor Tait, Great Britain.

Group has been assigned the task of accelerating preparations for jet navigation on a global basis. Timetable for completion of its work is late 1957.

State Dept. Calls Air Review Meeting

State Department is sponsoring a top-level aviation meeting in Washington, D. C., Nov. 14-16 for a complete review of developments bearing on international relationships between U.S. and other governments.

Particular emphasis will be placed on international aspects of commercial jets.

Invitations, sent out by Herbert Hoover, Jr., Undersecretary of State, went to presidents and vice presidents of aircraft companies involved in development, airlines with international operations, various governmental agencies concerned with international aviation and other interested groups.

ATA Shows Movie Over PNYA Objection

Over the objections of the Port of New York Authority, the Air Transport Association this month showed its new movie, "Mr. Withers Stops the Clock," to the press in New York.

The movie, intended to show the importance of an airport to a community, has been strongly criticized by PNYA, which said it contains "many critical public relations errors." In the film, Mr. Withers is a spirit-like character with magical powers who closes an airport because he doesn't like noise and is generally opposed to progress. The movie shows the effect of the closing on various people and industries.

• **Austin J. Tobin,** PNYA's executive director, said the film "is in exceedingly bad taste. It is an offensive caricature of respected . . . public officials . . . who have responded to the complaints of their citizens about what they consider to be the excessive noise of aircraft." He added that it "points the finger directly at Mayor Leo Carlin of Newark . . ."

Tobin said he would oppose any showings in the New York and New Jersey metropolitan areas.

ATA, however, showed the film to New York and New Jersey reporters on October 4. The showing was "hastily organized" because the press asked to see the movie in view of the controversy, ATA said. Reaction of Newark papers was that it did not caricature Mayor Carlin. PNYA was invited, but did not attend. Another press showing is scheduled for Oct. 25, to which PNYA has also been invited.

• **In a letter to Tobin,** ATA president Stuart G. Tipton said: "I am sorry that we cannot share your views. Nor do the others who have seen the film." Willis Player, ATA's v.p.-public relations, wrote John Wiley, PNYA's aviation director, that the film is the "first major tool developed . . . for telling on a national scale, the story of what an airport means to its community..."

He said he was perplexed by PNYA's criticism because the script had been shown to PNYA representatives, who said they had no objections. As a matter of fact, the PNYA officials suggested changing the name from "The Day They Closed the Airport," Player added.

New Firm to Produce Bellanca Cruisemasters

Production of the Bellanca Cruisemaster, suspended at the time of the Korean War, has been resumed by a new company in Alexandria, Minn. The company, Northern Aircraft, Inc., is incorporating some modifications to the four-place monoplane and is planning a a one-plane-per-week production schedule. Retail price has been set at $15,792.

The new Cruisemaster is powered by a 230-hp Continental engine, creating a cruise speed of 205 mph and a top speed of 220 mph. Range is pegged at 1,000 miles. Service ceiling is 20,000 and absolute ceiling 22,500.

New version includes choice of Hartzell constant speed or McCauley propellers. Modifications include new cowling, double sound barrier insulation, new manifold and heater arrangement, and auxiliary 15-gallon fuel tank as standard equipment.

An improved hydraulic system enables the landing gear to retract in about two seconds, the company says.

About 99 Cruisemasters were produced by Bellanca at the company's plant in New Castle, Del. The president of the new company, Roy Strong, purchased all rights of manufacturing and sales last November. The first new Cruisemaster recently was completed and flown.

Sud-Est Paves Way For Caravelle Visit

In preparation for a sales tour of the United States next year France's Sud-Est Aviation, manufacturer of the Caravelle, has opened a New York office at 500 Fifth Avenue, headed by Claude-Joseph Teyssier.

The jet transport is scheduled to be flown across the Atlantic early next year, probably toward the end of February, for demontrations in a large number of cities including New York, Washington, Miami, Atlanta, Boston, Denver, Chicago, Los Angeles and San Francisco.

The Caravelle will also be shown in Canada. After the completion of its North American tour it will be demonstrated in South America.

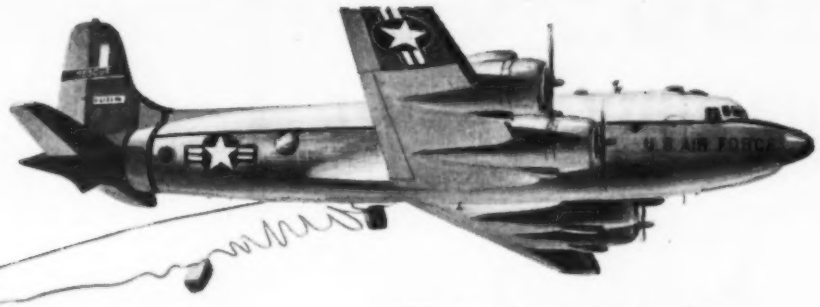
The demonstration aircraft will be the second prototype, which has now accumulated over 250 hours' flying.

Rep. Priest Dies

Rep. J. Percy Priest (D.-Tenn.), 56, chairman of the House Interstate and Foreign Commerce Committee, died Oct. 12 following surgery for an ulcer.

The former House whip had been one of the most active men in Congress on aviation matters. In the last session he sponsored the War Risk Insurance bill extending the legislation for five more years.

(*More news on page* 170)



This bombardier calls a near-miss perfect

Ranging over sea, desert, or frozen wastes, the Air Rescue Service's Douglas C-54s are an "anywhere—any weather" safety lifeline for downed airmen and disaster victims.

Greater speed and economy make the C-54 Skymaster ideal for both actual rescues *and* the long patrol missions Air Rescue Service flies. Increased fuel capacity keeps C-54 aloft for 18 hours or more. *One* plane can drop 4 new-type raft rescue kits with a life-saving potential of 160 people.

Defense is everybody's business. Global responsibilities tax our armed forces' manpower to the limit, and meeting them is a matter of national defense and national pride. Young Americans are urged to find out about the opportunities to serve their country and advance their futures in the service of their choice.

Depend on *DOUGLAS* First in Aviation

99.7%
Reliability Factor → IS EXPERIENCED BY TWA ON 749 Constellations

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VARIABLE DISPLACEMENT
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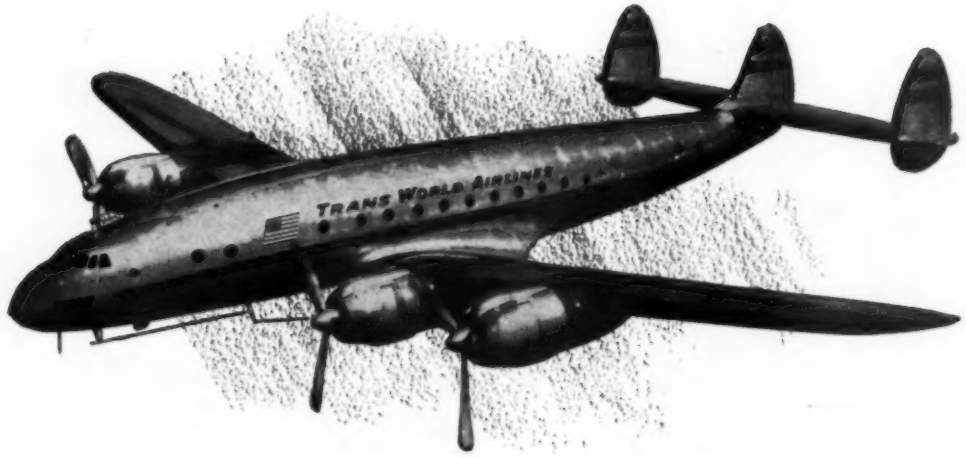

only 7 malfunctions in 2,026,064 pump hours

During a 5½ year period (July 1, 1949 to December 31, 1954) the TWA Accessory Shop overhauled 3000 Vickers Variable Displacement Pumps used on the cabin supercharger drives in their 749 Constellations. Of these, there were only seven malfunctions . . . all others were routine overhauls. In other words, only one of every 428 pumps scheduled for overhaul was for a malfunction. For the last three years the scheduled overhaul period for these pumps has been 1700 airplane hours.

Such reliability is another one of the reasons why TWA and other great airlines are large users of Vickers hydraulic equipment. For further information, ask for Bulletin A5203-A.

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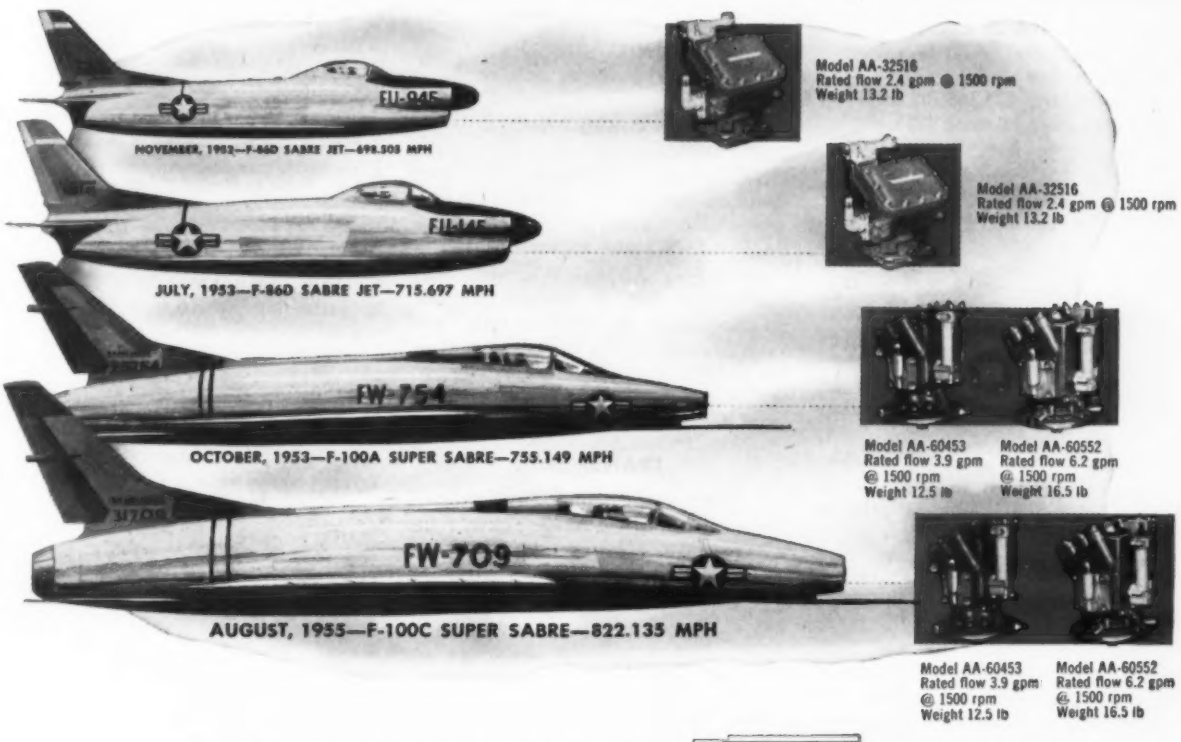
ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

WHERE *DEPENDABILITY* COUNTS MOST



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FOR THIS HISTORY-MAKING GROUP OF FIGHTER AIRCRAFT

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ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

News Briefs

MANUFACTURING—MILITARY

• **Douglas Aircraft Co.** reported net earnings of $20,595,609 on $711,285,995 sales for the nine months ended Aug. 31, compared with $23,368,508 profit on $679,157,313 sales in same 1955 period. Earnings dip was partly due to mounting development costs, mostly assigned to the stepped-up DC-8 program.

• **Recent missile contract awards** include: Raytheon Mfg. Co., $60-million Navy contract to manufacture Sparrow air-to-air missiles; Northrop Aircraft, $26-million USAF award for developmental production of the Snark SM-62 intercontinental missile.

• **North American Aviation's** F-107 fighter-bomber completed its second test flight without incident. On its first flight, the plane lost its nose gear when the drag chute failed to open during landing and it rolled into a depression in the desert at Edwards AFB, Calif.

• **The Glenn L. Martin Co.** has been allowed to announce that the Lacrosse surface-to-surface missile is in production for the Army. It is a close support weapon that can be parachuted along with its launching vehicle and guidance station from standard assault transports. Lacrosse system was developed by Cornell Aeronautical Laboratory in Buffalo and is being produced at Martin's Baltimore plant. Deliveries to the field are expected next summer.

• **AC Spark Plug Div.** of General Motors selected "Achiever" as the name for its guidance systems being developed for ICBM, Matador and other missiles.

• **Topp Industries Inc.** has acquired Heli-Coil Corp. in exchange for 100,000 shares of Topp's common stock, $900,000 of 3% convertible subordinated debentures, and $300,000 cash. Headquarters of the merged companies will be in Los Angeles. Eduard Baruch, Heli-Coil president, becomes a vp and director of Topp.

• **Bell Aircraft Corp.,** Ft. Worth, was awarded a $57,719 contract by Army Transportation Research and Development Command to conduct a parametric design study of a heavy-lift flying crane helicopter. Bell is the sixth company to receive such a contract.

• **August exports** of utility airplanes totaled 88, valued at $1,180,166 to 24 nations, Alaska and Puerto Rico, Aircraft Industries Association reported. This was 144% over the same month last year. Total shipments for the first eight months of 1956 totaled 596 planes (of 6,000 lbs. or under) worth $7,476,103, up 36% over same 1955 period.

• **Beech Aircraft Corp.** phased out production of the USAF T-34A Mentor trainer with completion, on schedule, of its 300-plane order covering a 40-month period.

• **Transland Company's** AG-2 agricultural plane made its first flight at Torrance, Calif., airport on Oct. 12.

• **Kaman Aircraft Corp.** completed engine run-up and hovering tests of the HOK-1 helicopter which had been modified for a Lycoming XT53 free-shaft turbine engine instead of the usual P&W R-1340 piston engine.

• **Boeing Airplane Co.** will complete more than $5 million of additional facilities at Wichita early next year. They include a large hangar capable of housing four B-52 jet bombers and a second hangar to be used for paint and finish work.

TRANSPORT

• **Permanent status** for Northwest Airlines' Seattle-Anchorage-Tokyo route has been recommended by CAB Examiner Edward T. Stodola. The route was renewed temporarily last year, but when operations became subsidy-free NWA applied for permanency. An examiner's report is expected soon on Pan American World Airways' application for a Great Circle route in the Pacific.

• **CAB** said in a press release that it will certificate Lake Central Airlines for a new segment between Cincinnati, Portsmouth and Columbus, Ohio, for three years or until completion of the Great Lakes Local Service Area Case. Cincinnati-Columbus flights must serve Portsmouth. Board will issue a written opinion and order later.

• **Western Air Lines** stockholders voted to end cumulative voting for directors. A company-sponsored move to delete this voting provision from the certificate of incorporation overrode the opposition of directors William S. Bartman and Gordon Y. Billard.

• **Northeast Airlines** plans to start service between New England cities and Washington Nov. 27. Convairs will be used initially. This is the first step in NEA's expansion program authorized by CAB in the New York-Florida case.

• **Mohawk Airlines** has contracted with William C. Wold Associates for sale of one of its Convair 240s. The plane is one of the four the company originally had and not one of the seven acquired from Swissair.

• **Airlines received** over 50% of the Defense Department's expenditure for passenger travel within the U.S. in fiscal 1956. Of $102,816,717 total, $54,509,745 went to commercial air, $34,698,112 for rail, $7,611,338 for bus, and $5,997,522 for Pullman.

• **Passenger revenues** of domestic trunk and local service airlines totaled $582 million in the first six months of 1956, against rail passenger revenues (excluding commutation) of $315.7 million. Air was up $65.8 million over same 1955 period, while rail rose only $4.9 million.

• **CAA has awarded** three more contracts for its fiscal 1957 airways program: Kaar Engineering Co., Palo Alto, Calif., $409,667, for VHF transmitters and spares; Gruen Watch Co., Cincinnati, $318,955, for 1,545 VHF aircraft receivers and spares; Sylvania Electric Products, New York, $22,270, for airport flashing approach lights at Boston's Logan International Airport.

• **David Cole,** acting as neutral fact-finder, took over the job of refereeing the labor dispute between National Airlines and the Air Line Pilots Association. Negotiations bogged down several weeks ago.

• **Forty-three property owners** near Seattle-Tacoma Airport have asked compensation for alleged noise and vibration damage to property values. Defendants include Port of Seattle, Alaska Airlines, Northwest Airlines, Pacific Northern, Pan American, United, Western and Trans-Canada. Similar suits totaling over $1 million have been filed against the airport in the past year.

• **TWA and American Export Lines** are offering packaged "sea-air cruises" to Europe, in what the companies refer to as a "new travel concept." Arrangement calls for a sea journey to Europe, tours through Europe, and return to New York via TWA.

• **Change in the system** of paying United Air Lines navigators will result in monthly wage increase of $195, Transport Workers Union says. Under the plan, a pay formula scheme, navigators flying 85 hrs. a month, half day and half night, will earn $1,032.79, industry's highest rate. They previously earned $837.50 on a monthly pay basis, TWU explains.

• **KLM Royal Dutch Airlines** has doubled its transatlantic all-cargo service and is now operating six roundtrips weekly, two with DC-6As and four with DC-4s.

• **CAB approved** the service of W. A. Patterson, United Air Lines president, as a director of UAL and of Goodyear Tire & Rubber Co. There is no "potential conflict of interest" in the UAL-Goodyear relationship, CAB said. It deferred action on Patterson's directorship in Westinghouse Electric Corp. until investigation is completed.

(*More news on page* 174)

Rascal the strike from "nowhere"

Bell Aircraft's GAM-63 Rascal is an air-launched guided missile designed to carry out bombardment of strategic military targets—*without the need of bombing runs on the target.*

Rascal is carried by USAF long range bombers and released miles away from its destination, with the bomber well outside the perimeter of local defenses. Then, while Rascal is speeding one way towards the target, the bomber already is headed for its home base in the opposite direction.

In this manner, Rascal could extend the useful life of the nation's bombardment aircraft and eliminate many hazardous operations for the crews of these bombers, thereby fulfilling two important economic and human goals of a strong Air Force.

The rocket-powered Rascal's ability to hit a target while the bomber aircraft is miles away has been demonstrated in a flight test program conducted in conjunction with the Air Research and Development Command.

Bell Aircraft has the weapon system responsibility for Rascal and with the cooperation of its many subcontractors, has developed the electronic, servo and propulsion systems for this air-to-surface missile as well as the airframe, launching, ground handling and training equipment.

The Air Force-Industry team urgently needs scientists and engineers for projects vital to the nation's defense. Opportunities to make important contributions are offered in military or civilian careers.

BELL Aircraft CORP.

BUFFALO N.Y.

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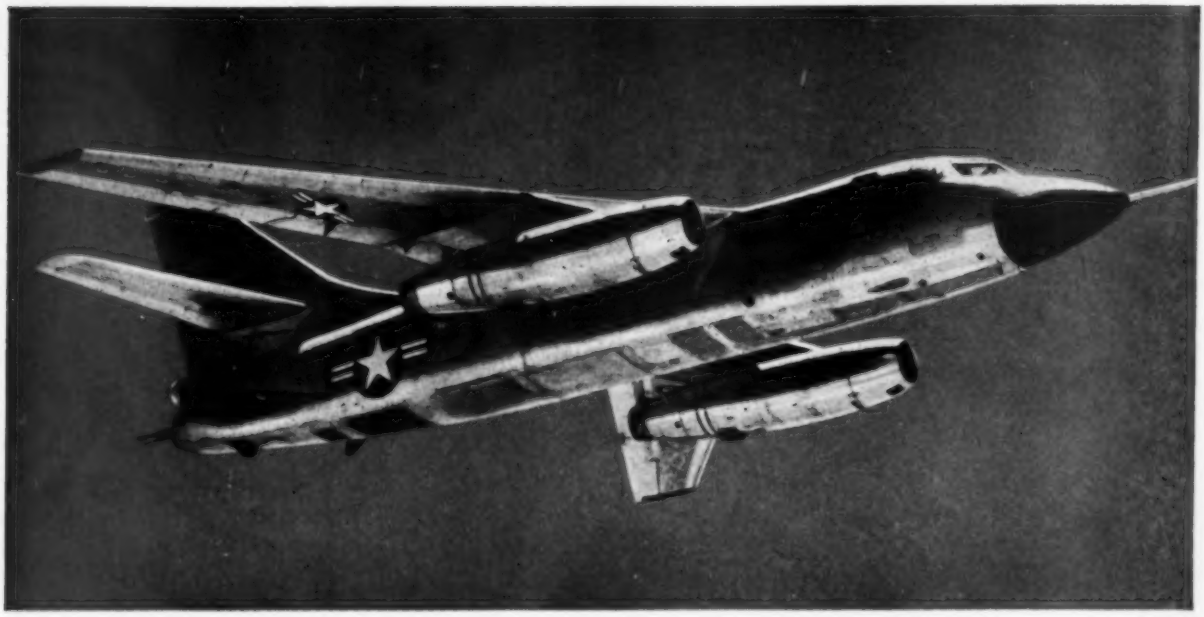
"EYES" FOR THE AIR FORCE TACTICAL AIR COMMAND



Air Force RB-66 powered by Allison J71 Turbo-Jet Engines

Here you see the Tactical Air Command's newest reconnaissance bomber—the all-weather twin-jet Douglas RB-66.

It carries a payload of nuclear or conventional bombs—which it can wing at 600-700 mph to targets dictated by the nation's needs.

It packs a full complement of camera equipment —which also makes it a valuable reconnaissance tool for air intelligence.

And in pods under its wings it boasts a pair of Allison J71 Turbo-Jet engines — each producing 10,000 pounds' thrust without augmentation — which take it to altitudes over 40,000 feet.

Now winning its wings for reliability and dependability with the 363rd Tactical Reconnaissance Wing at Shaw Air Force Base, S. C., the Allison-powered RB-66 carries a three-man crew as it goes on its peace-maintaining missions.

The Allison-powered Douglas RB-66 is another example of how continuous engine development —both Turbo-Jet and Turbo-Prop—is helping keep America first in the air.

ALLISON DIVISION OF GENERAL MOTORS, Indianapolis, Indiana

ALLISON
TURBO-JET
AND TURBO-PROP POWER

GM
MORE POWER FOR YOU

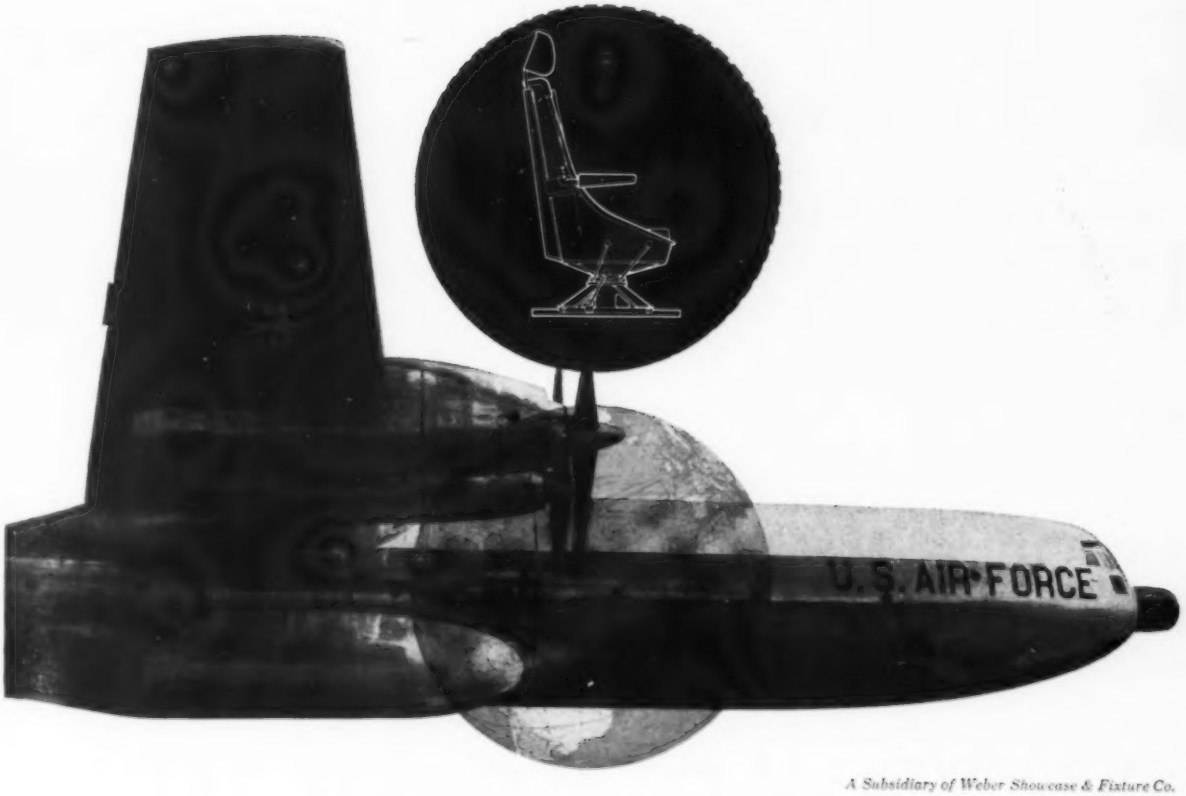
AMERICAN BUILT FOR THE JET ERA IN AIR TRAVEL

The Douglas C-133A

is a giant among cargo carriers.

Navigator seats for these behemoths

are designed and built by Weber.



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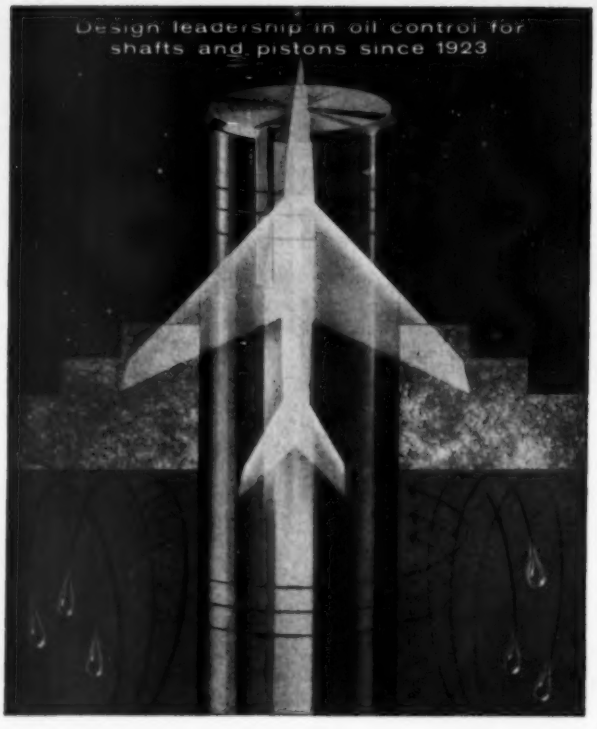

HIGH SPEED shaft sealing problems?

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To designers and builders of jet or reciprocating engines and auxiliaries, SIMPLEX offers exclusive design principles and extended industry experience in solving similar problems. SIMPLEX products are original equipment in Allison, Pratt & Whitney, Wright and other leading aircraft engines.

Whether your oil control problems involve shaft seals or piston rings, SIMPLEX engineers will be glad to help you work them out. Call, wire or write.

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Circle No. 137 on Reader Service Card.

Industry News Digest

Glass That Won't Globulate

An awkward requisite of manned flight is that the pilot's supposed to see where he's going. To date this requirement has been filled with everything from scanty open-cockpit windshields to great shining plastic bubbles and thick framed glass sections.

But with the advent of high-super-to-hyper-sonic flight, conventional materials simply melt and glob away. Thus another "worst" problem facing aircraft engineers is how to arrange for the pilot to see through hot air.

Current thermoplastics such as the acrylics are good to about 200°F. Work with these will probably extend their usefulness to 300°F or slightly over. Next come the thermo-setting plastics such as the polyesters, phenolics, epoxies and silicones.

If these can be developed with good light transmission and optical properties, they will be useful to about 600°F. One trouble is their brittleness, which may make lamination necessary, as in glass.

Meanwhile, for higher temperatures still, fully tempered glass such as that used in the X-2 and X-3, is stable and usable to 1,000°F. After that comes fused quartz in the 1,800° range.

P&W Promotes Three

Three major promotions were announced by Pratt & Whitney Aircraft division of United Aircraft Corp. to meet expanding operations both in Connecticut and in Florida.

Leonard C. Mallet was advanced from assistant general manager of P&W Aircraft to general manager of Connecticut operations.

Charles T. Roelke, former executive assistant to the general manager, was named general manager of Florida operations.

Newton V. Turney, who rejoined P&W several weeks ago after resigning from Chance Vought, was named divisional controller of Florida operations.

Wright A. Parkins, vice president of United Aircraft, has relinquished his post as general manager of all P&W operations.

However, he continues to represent the division as its chief executive and as a member of the corporation's operating and policy committee, and Mallet and Roelke report directly to him.

MATS Want Big Jet Transports

The Military Air Transport Service is continuing with its campaign to convince the world that it needs large jet transports to carry out its mission, but so far there has been no indication that anyone in the Pentagon has been listening.

In a recent radio interview sponsored by the American Legion, Lt. Gen. Joseph Smith, MATS commander, said his organization would like to have the big jets to move combat troops, fissionable material, whole blood and other high priority cargo. It should have a range of at least 5,000 nautical miles, he added.

He also said MATS required a large turboprop cargo carrier with a range of at least 3,500 nautical miles and 5,000 nautical miles if possible.

The service is scheduled to get deliveries next year of the Douglas C-133 turboprop transport, which will meet this need.

MORNING 'TIL NIGHT
EVERY HOUR ON THE HOUR

NONSTOP BETWEEN

NEW YORK-CHICAGO

From 8 am to 9 pm New York to Chicago and 7 am to 11 pm Chicago to New York

AA AMERICAN AIRLINES
Americas Leading Airline

The exclusive log-book record of the Bristol Britannia's recent U. S.-Canadian tour . . . how the "Whispering Giant" made an extraordinary flight operation possible.

Minutes before midnight, Sunday, August 12, a new Bristol Britannia turboprop airliner swept down a London Airport runway en route for Montreal.

Aircraft Baker-Jig was fresh from the production line. Tenth of thirty-three Britannias being built for B.O.A.C., she had logged exactly twelve hours' flight time before takeoff. Aboard were a special Bristol demonstration team set to show U.S. and Canadian aviation experts what their "Whispering Giant" could do.

This was the beginning of a historic tour that went like clockwork all the way. From the flight-log, here are excerpts that highlight the remarkable achievements of this unique flight operation:

London-Montreal in 10 hrs. 54 min. Over 3,400 miles non-stop against 40-mile headwinds.

Monday, August 13: Landed Idlewild, New York 7:33 a.m. On schedule. Ready for demonstration flight in 30 min. Total of 42 airline executives, 57 press members greatly impressed by Britannia's performance, particularly low-noise level. Demonstrations complete, prepare for nonstop transcontinental trip, New York-San Diego, carrying 18,000-lb. payload.

Tuesday, August 14: Strong headwinds, severe storms, cause wide detour. Britannia still makes nonstop trip in only 8 hrs. 26 min. Arrives San Diego with airline representatives aboard delighted by smooth, comfortable ride.

Sunday, August 19: Winding up successful West Coast tour. Remarkable reception at San Diego, Burbank, Los Angeles airports. Over 30,000 visitors walk through and inspect aircraft. Los Angeles reports 200 phone calls per hour from people eager to see "Whispering Giant."

Monday, August 20: Vancouver-San Francisco, 2 hrs. 59 min. Tuesday, San Francisco-Denver. Wednesday, Denver-Chicago. Demonstration flights in each area. Enthusiastic reception each stop for Britannia.

End Phase #1: "Operation Clockwork" aims to cover 28,000 miles in 18 days. Total time to date, 31.24 hrs. Total distance, 8,650 miles. Engineers report perfect mechanical

conditions, engine cowlings remain unopened since London.

Thursday, August 23: Chicago-New York after historic tour of seven major U.S., Canadian cities. "Whispering Giant" receives enthusiastic reception everywhere. Log shows 37 flying hours, 11,000 miles, 825 airline executives and press representatives carried to date.

Saturday, August 25: New York-Miami, where Florida is visibly impressed by the Britannia . . . the Governor of the Bahamas requests the "Whispering Giant" to make a special fly-past.

Monday, August 27: Miami-Washington, D. C. where officials praise Britannia's extremely low noise level and remarkable reliability.

Thursday, August 30: Peter Masefield, Managing Director, Bristol Aircraft Ltd., cables London: "Two demonstration flights from New York 29th. Reliability demonstrated on tour has created profound impression all airlines. Now only last lap to go."

Friday, August 31: Despite adverse weather, Britannia Baker-Jig flies nonstop Idlewild-London in 10 hrs. 18 min.—the only successful nonstop crossing that night. The "Whispering Giant" completes historic "Operation Clockwork" 100 flying hours after rolling off the production line ...88 flight hours, 24,000 miles after take-off from a London Airport runway.

From the record—for the record books: Britannia Baker-Jig was the first turbine-powered airliner ever to fly New York-London nonstop . . . and yet this is only the *medium-range* Britannia.

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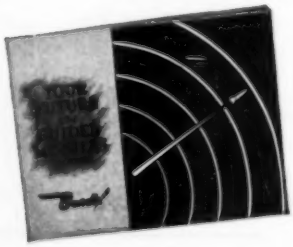

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Facilities

Convair starts construction this month on a $2-million high altitude test facility at its Ft. Worth, Tex., plant. Project includes three test cells capable of simulating altitudes up to 100,000 ft. at temperatures ranging from minus 100°F to 500°F.

Air Products Inc., Allentown, Pa., will start construction this year of a $2,810,000 liquid oxygen generating plant on a three-acre site adjacent to the new Martin Titan ICBM plant near Denver, Colo. Output will be delivered to Martin for use in static ICBM test firings. Facility will be sold to USAF when completed, and leased back to Air Products for operation.

Helipot Div., Beckman Instruments Inc., completed its move from S. Pasadena to temporary quarters in Costa Mesa, Calif., preparatory to occupancy of a new $2-million plant early next year in Newport Beach.

Airwork Corp. has opened a branch office and warehouse in Hangar 8, Cleveland-Hopkins Airport, Cleveland, O.

Cook Electric Co. will open the Cook Technological Center in Morton Grove, Ill., this month. It will be operated by more than 1,000 research scientists, engineers, technicians and other personnel.

Levinthal Electronic Products Inc. started construction of a 55,000-sq.-ft. facility in Stanford Industrial Park, Palo Alto, Calif., to augment present facilities in nearby Redwood City.

Lundy Mfg. Corp. doubles capacity of its present plant at Long Island City when it moves into a new facility at Glen Head, L. I., in December. Company makes aircraft actuators, lightweight motors and control valves.

Pacific Scientific Aeroproducts will start construction of a new plant and office building in Anaheim, Calif. Company manufactures aircraft accessories and instruments, which are sold through an affiliate, Pacific Scientific Co.

U.S. Electronics Corp., Glendale, Calif., will build three 20,000-sq.-ft. manufacturing facilities in North Hollywood, Calif. Construction will start early next year.

Lear Inc.'s Lear-Romec Div., Elyria, O., will occupy a new 14,000-sq.-ft. addition to its plant this month. Total space will be 74,000 sq. ft.

Zero Mfg. Co. has completed its plant expansion program in Burbank, Calif. Company makes deep-drawn aluminum cases, boxes, instrument cases and combination carrying cases for the electronics and aircraft industries.

General Electric has expanded the product line responsibility, plant facilities and engineering manpower of its aircraft products department, with headquarters at Johnson City, N. Y. Activities of the Schenectady aeronautics and ordnance operation have been consolidated with the department, and the Schenectady operation has been discontinued as an organizational unit. Consolidation provides the aircraft products department with engineering and manufacturing facilities in Schenectady and at Coxsackie, N. Y., in addition to similar facilities it formerly had at Johnson City and Burlington, Vt. Department's employes will now total 4,900, including over 450 engineers.

Hamilton Standard Division of United Aircraft Corp. acquired title to a 290-acre permanent site for its Florida engineering operation announced last Spring. Site is on the outskirts of St. Petersburg. No manufacturing operations are contemplated at the facility.

Norden-Ketay Corp. has started construction of a building in Stamford, Conn., to house its executive offices, now located at 99 Park Ave., New York City. Plans call for an additional building in which to establish a central research laboratory for the company's missile work.

Graphik Circuits, manufacturer of etched circuits, will move next month into its new facility in Puente, Calif.

Electro-Measurements Inc. has moved into its new building at 7524 S. W. Macadam Ave., Portland, Ore. Firm designs and manufactures precision impedance and comparison bridges, decade resistance and capacitance standards, and high linearity voltage dividers.

General Precision Laboratory Inc. started construction of a new engineering building at its Pleasantville, N. Y., plant. Completion is expected in July, 1957.

Clark-Aiken Co., of Lee, Mass., producers of precision machined custom parts for aviation and other industries, opened an office at 114 E. Union St., Pasadena, Calif.

a Campus way of life for creative engineers

Here at McDonnell Aircraft Corporation aeronautical engineering history is being made by our new "Engineering Campus." The architect's rendering of this 16-acre development adjoining our plant gives an idea better than any words of the great steps being taken at McDonnell to provide its engineers with a new kind of work environment for creative thinking and effective achievement.

The development's imaginative scope, colorful beauty and detailed attention to working comfort are attracting nationwide attention as a logically ultimate answer to a vital need of the aircraft industry. One building is completed and occupied, and a second is already under construction. The entire group upon completion at a cost of more than $6,000,000 will comprise integrated facilities of, by and for engineers.

This latest chapter in McDonnell's record of pioneering achievements is another significant indication why the company in only 17 years has grown from two individuals to a team of more than 17,000 persons. We are now working on a backlog of orders for fighters, missiles and helicopters that exceeded two-thirds of a billion dollars on June 30.

Newest McDonnell planes in production for national security are the versatile F3H-2N Demon, fastest all-weather fighter in the Navy, and three different versions of the world's most powerful fighter, the supersonic F-101 Voodoo, for the Air Force. Work is in progress on four advanced missiles, including Talos.

We salute the engineers who have done so much to make possible our contributions to the nation's airpower. We believe a good part of the accomplishments stems from a fundamental policy that takes into account the highly individual capacities and aspirations of able and productive men. The "Engineering Campus" program is our direct-action pledge to our engineers—those now at McDonnell and those who will join them—that we are determined to maintain and develop further an environment that fosters the sort of creative achievements on which continued progress depends.

Professional and economic advancement await qualified engineers at McDonnell Aircraft. We provide free in-plant engineering courses taught by our own top engineers and sponsor graduate and undergraduate programs at the two outstanding universities in St. Louis. We invite you to investigate joining our team of the ablest minds in aeronautics — united in making fundamental progress in advanced airplanes, helicopters and guided missiles—by writing to R. F. Kaletta, Technical Placement Supervisor.

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THE COLUMBUS DIVISION OF

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ADVERTISERS' INDEX

	Page
A C Spark Plug Div., General Motors Corp.	93
Adams-Rite Manufacturing Co.	165
Adel Precision Products, Div.-General Metals Corp.	59
Aero Design and Engineering Co.	67
Aerojet-General Corp. (Sub. of The General Tire & Rubber Co.)	16 & 17
Aeroquip Corp.	13
Airborne Accessories Corp.	141
Aircraft Radio Corp.	153
Air Cruisers Co., Div., The Garrett Corp.	109
Allison Div., General Motors Corp.	172
American Airlines, Inc.	175
Amphenol Electronics Corp.	66
Avco Manufacturing Corp.	18 & 19
Beech Aircraft Corp.	163
Bell Aircraft Corp.	171
Bendix Aviation Corp.	
Bendix Products Div.	63
Pacific Div.	5
Scintilla Div.	129
Bristol Aeroplane Co., Ltd., The	176 & 177
Bulletin Board (Classified)	178 & 179
Canadair Limited	103
Cannon Electric Co.	22 & 23
Capital Airlines, Inc.	12
Cee-Bee Chemical Co., Inc.	138
Chance Vought Aircraft, Inc.	73
Chandler-Evans, Div., Pratt & Whitney Co.	69
Commonwealth of Pennsylvania, Department of Commerce	143
Continental Air Lines, Inc.	139
Continental Motors Corp.	96
CONVAIR—A Division of General Dynamics Corp.	51
Cooper Precision Products	86
Curtiss-Wright Corp.	65
de Havilland Aircraft Co., Ltd., The	91
Douglas Aircraft Co., Inc.	167
EMPLOYMENT SECTION	
Bendix Aviation Corp., Bendix Products Div.	180
McDonnell Aircraft Corp.	179 & 181
North American Aviation, Inc., Columbus Div.	182
Esso Export Corp.	14
Flightex Fabrics, Inc.	134
Flight Refueling, Inc.	57
Ford Instrument Co., Div. of Sperry Rand Corp.	127
General Electric Co.	10 & 11
Aircraft Gas Turbine Div.	131
General Laboratory Associates, Inc.	145
G. M. Giannini & Co., Inc., Airborne Instrument Div.	8
B. F. Goodrich Co., The	34
Goodyear Tire & Rubber Co., Inc., The	3
Hertz Rent A Car System	15
Hiller Helicopters	4
Hitemp Wires, Inc.	133
Hollywood Roosevelt Hotel	156
Hydro-Aire, Inc.	101
Indiana Gear Works, Inc.	97
International Business Machines Corp., Military Products Div.	33
International Electronic Research Corp.	21
Jack & Heintz, Inc.	155
Janitrol Aircraft-Automotive Div., Surface Combustion Corp.	160
Joy Manufacturing Co.	107
Kasar Mfg. & Distributing Co., Inc.	79
Kearfott Co., Inc.	26
Kollsman Instrument Corp., Sub.-Standard Coil Products Co., Inc.	20
Laminated Shim Co., Inc.	30 & 31
Hotel Lexington	135
Link Aviation, Inc.	85
Lockheed Aircraft Corp.	60 & 61
Loral Electronics Corp.	28
Menasco Manufacturing Co.	83
Minneapolis-Honeywell Regulator Co., Aeronautical Div.	99
Motor Generator Corp.	125
D. Napier & Son, Ltd.	32
National Aircraft Corp.	29
Nems-Clarke, Inc.	130
New York Air Brake Co., Watertown Div.	121
Northrop Aircraft, Inc.	52 & 152
Orenda Engines Limited	I
John Oster Mfg. Co., Avionic Div.	89
Ouest Aviation	87
Pan American-Grace Airways, Inc.	105
Pastushin Industries, Inc.	12
Pratt & Whitney Aircraft Div., United Aircraft Corp.	142
Purolator Products, Inc.	77
Resistoflex Corp.	104
Ralph C. Robinson Co.	156
Robinson Aviation, Inc.	62
Rodney Metals, Inc.	124
Rolls-Royce, Limited	27
Sarkes Tarzian, Inc., Rectifier Div.	164
Scandinavian Airlines Systems	119
Scott Aviation Corp.	71
Scovill Manufacturing Co.	148
Simmonds Aerocessories, Inc.	75
Simplex Piston Ring Manufacturing Co.	174
Sinclair Refining Co.	24 & 25
Sperry Gyroscope Co., Div. of The Sperry Rand Corp.	112
Stewart-Warner Electronics, a Div. of Stewart-Warner Corp.	88
Stratos, a Div. of Fairchild Engine & Airplane Corp.	185
Stroukoff Aircraft Corp.	147
TECO, Inc. (Transport Equipment Co.)	128
Temco Aircraft Corp.	149
George A. Terry Co.	132
Texas Co., The	186
Trans World Airlines, Inc.	115
U. S. Time Corp.	81
United Air Lines, Inc.	95
Vertol Aircraft Corp.	137
Vickers Armstrongs (Aircraft) Ltd.	6
Vickers Inc., Div. of The Sperry Rand Corp.	168 & 169
Voi-Shan Mfg. Co., a Div.—Pheoll Mfg. Co.	157
Wakmann Watch Co., Inc.	132
Watertown Div., The New York Air Brake Co.	121
Weatherhead Co., The, Aviation Div.	55
Weber Aircraft Corp.	173
Western Gear Corp.	117
Weston-Hydraulics Ltd., Sub. Borg-Warner Corp.	120
Wm. R. Whittaker Co., Ltd.	161
Wilcox Electric Co., Inc.	2
Winslow Manufacturing Co.	136
Yardney Electric Corp.	140

Merger of Northrop, Vertol in Offing

Wedding bells were in the air this month for Vertol Aircraft Corp. and Northrop Aircraft, Inc., as officials of the two companies got down to some serious merger talks.

Whitley Collins, president of the Hawthorne, Calif., airframe and missile firm made the first move with an offer of two shares of Northrop stock for each share of Vertol outstanding after the latter company's 15% stock dividend goes into effect October 29.

Don R. Berlin, president and chairman of Vertol, made it plain that Collins' offer has attractions for his Morton, Pa., helicopter firm. "Vertol's growth could be accelerated by combining with a large manufacturer such as Northrop," he said. "The activities of both companies complement each other. These exploratory talks will determine the advisability and practicability of a combination of the two companies."

So interesting were the exploratory discussions with Northrop that the Vertol board of directors authorized its management to "widen" the field of its talks with the California company. But Berlin cautioned that the two companies still must reach agreement on many points before a merger can be realized.

If an agreement is worked out, he said, it will go to the Vertol board for approval, and then it will be proposed to Vertol shareholders for a vote.

Northrop was quoted in a $23-$24 price range on the New York Stock Exchange in the early part of the month, while Vertol was being quoted in over-the-counter transactions at $52.50 asked and $48.50 bid.

State Officials Elect Abney President

A. E. (Gene) Abney of Illinois was elected president of the National Association of State Aviation Officials at the annual meeting at Lake Placid, N. Y., this month.

Other new officers: George Nelson, Wyoming, 1st v.p.; James Martin, Tennessee, 2nd v.p. Re-elected were E. F. Knapp, Vermont, treasurer, and A. B. McMullen, executive secretary.

New regional officers: Region 1, Robert Nuber, Washington; Region 2, Dale Fearn, Missouri; Region 3, Richard Cunningham, Indiana; Region 4, Rudolph Drennan, Maryland; Region 5, H. B. Wetherell, Conn.; Region 6, Vincent Fitzgerald, Arizona; Region 7, T. B. Herndon, Louisiana; Region 8, C. B. Culbertson, South Carolina.

The Little People of the Belgian Congo

In the Belgian Congo are to be found both the shortest and tallest people in the world.

On my Sabena trip I saw the pygmies first. I had thought before going to Africa that the pygmies were a small isolated tribe and that they were short because of malnutrition or some sort of disease.

Quite the contrary, the pygmies were the original occupants of the Congo. There are about 100,000 of them and they are found in a fairly wide area in the northeast. On my trip I saw several thousand.

They're five feet tall and less. Many of the women are closer to four feet. They're fully developed people. It just happens that they are miniatures and have been that way for centuries. Their history goes back thousands of years.

They live chiefly in the forest. When the taller natives moved in from the north long ago, the pygmies were driven deeper into the Congo forest and only in recent years have they been coming out closer to civilization. But even today there are many pygmies who are frightened at the sight of a white man. I saw many who ducked quickly into the protection of the jungle when being approached.

But our press group did get close to quite a few who have accepted the presence of Europeans and who aren't averse to earning some coins by posing for the camera.

Taxed 30¢ A Year

They don't like to work. Or if they do work, they earn enough for some beer or metal for arrows or knives and don't show up again for a long time. Somehow or other the government has been able to keep track of most of them and taxes each pygmy about 15 francs, or 30 cents, per year. Nowadays the pygmy seems to look to the native for protection against wild life and for food, and in turn the pygmy does some hunting for the native. The average pygmy is a mighty fine shot with a bow and arrow. I wouldn't want to be on the receiving end of an attack from those little people.

One of the most amazing evenings I've ever spent in my life was in a clearing in the forest a few miles from the Mount Hoyo Hotel operated by Mr. and Mrs. Jean Borckmans. Mr. Borckmans is an expert on pygmies and arranged for us to see a night dance by the local tribe. It was only the third time that such a performance has been given at night.

By the light of a couple of acetylene lanterns, we made our way from the road by a winding trail to the clearing. The pygmies have no light at all except from their fires, so the two lamps were set out in the clearing while the pygmies staged a series of extremely primitive dances in a completely weird atmosphere.

The music consisted of a single drum and a couple of reed horns, all very monotonous. The rhythms were all simple and primitive. The first dance was about elephants and the second was about baboons. Then came the chimpanzee dance and I am here to testify that it was one of the most fascinating things I've ever witnessed.

These pygmies imitated every movement and gesture of chimps. In the semi-darkness they could easily have been mistaken for the animals themselves. In fact the whole performance in the African jungle seemed to whisk all of us back into life as it was many centuries ago. The pygmies themselves were virtually naked and the only modern item at all was the two acetylene lanterns, and our small group from the U.S. And I might add, although I hope you don't think body odors have become too much of an obsession with me, that you could cut the odors with a knife.

After the pygmy performance the local natives put on a show of their own. They were decorated with elaborate headdresses and paint, and the rhythm was much more pronounced and advanced. One dance involved a man trying to get out of bed against the objections of his wife and it was acted out pretty realistically although Mr. Borckmans said the natives toned it down because of the visitors. But the natives and pygmies on the sidelines howled with laughter throughout. They were entranced by the playing out of a centuries-old tale that had been handed down from generation to generation.

We were in an area a long way from civilization. Our hotel, which was actually more of a camp, was just adequate as a tourist stop. The nearest postoffice and trading village were many miles away. The natives hereabouts had never seen moving pictures or much of any kind of life as it exists around the world.

One modern accomplishment acquired by the natives, however, is the ability to light a cigaret, stick the lighted end inside the mouth, and proceed to smoke. Everybody including kids seemed to be able to do it. What price the white man's civilization!

Our hero, WWP, whose height is only five feet six and a half inches, towers above newly-found pygmy friends.

A common sight in Belgian Congo: pygmy women on road carrying all sorts of things on their heads.

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- *Travel equal to total length*

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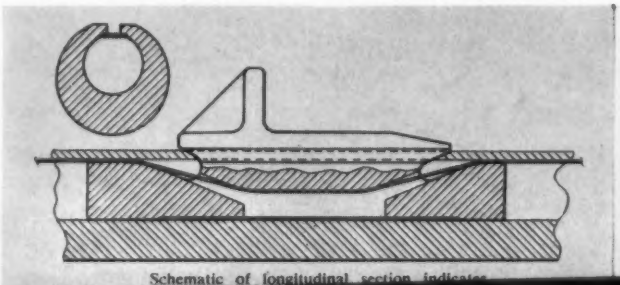

Schematic of longitudinal section indicates

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